ASSESSMENT OF A WASTE OUTFALL LOCATION 1970-72

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Ministry
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1970-2

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SUMMARY

Water movements and temperatures were measured in the near shore regions of Lake Ontario, adjacent to the Etobicoke Creek outlet during the periods May to December, 1970, December 1971 to March 1972 and June and July 1972. These studies were designed to identify spatial and temporal water movement and temperature variations to assist in the location of a waste outfall. Water movement data can be used in models to estimate the effect of an effluent on nearby intakes. As the volume of discharge in the existing plant will be significantly increased, possible adverse effects on the proposed recreational shore development and fishery must also be assessed.

Three positions were examined as possible outfall locations and two locations on either side of the R.L. Clark water intake were examined to determine water movement patterns in the immediate vicinity of the intake. A location in 9.5 m of water and 2.5 km offshore was considered the best outfall site. The currents moved from the selected location towards the R.L. Clark water intake 25, 23 and 41 percent of the month during November 1970, December 1971 and January 1972, respectively. For all the other seven monthly periods, movement from the selected location towards the intake occurred 5 to 18 percent of the time.

One and two-dimensional dispersions were computed utilizing Markov chain techniques on the fixed point current meter data. These indicate that the spatial separation between the selected location and the intakes is adequate to maintain water quality at the intakes with dilution factors of 0.025 to 0.013 neglecting initial mixing.

The comparison of total coliform counts and free ammonia (NH_3) concentrations at the R.L. Clark intake with current directions at the selected locations reveal that high coliform readings were statistically associated with water movement towards the southwest at a 98 percent confidence level. No similar trend could be found in the NH_3 data for the 1970 and 1972. Some high total coliform counts and NH_3 concentrations were observed during periods of no water movement or when movement was either on or offshore.

The currents moved from the selected location towards the intake on the average 16 percent of the time during the period of study. The maximum period when currents prevailed in that direction was 44 hr at a mean velocity of 15 cm/sec. It is advisable to include a properly designed diffuser. The diffuser would increase dilution by initial mixing during periods of unfavourable water movements and reduce buoyancy effects. Initial mixing from the multiport jet diffuser normally increases dilution of an effluent by a factor of 4 to 10 over a buoyant single port discharge. Dilution is also increased for a denser effluent by a factor of 2 to 3. One multiport diffuser design would be 30 ports (0.61 m diameter)

at 6.1 m centres. In addition to the dilutions due to dispersion, this diffuser will provide dilution factors of approximately 0.025.

RECOMMENDATIONS

It has been concluded that an outfall at the selected location will have no adverse effect on the municipal and industrial water intakes, recreation areas and on fisheries in the region. Therefore, it is recommended that the proposed outfall be located in 9.5 m of water and 2.5 km offshore. Such an outfall should also have a properly designed multiport diffuser (Appendix IV) to increase the initial dilution by a factor of 4 to 10. The diffuser will also reduce buoyancy of the effluent and thereby reduce the surfacing characteristics of effluent minimizing aesthetic pollution.

ASSESSMENT OF A WASTE OUTFALL

LOCATION 1970-2

1.0 INTRODUCTION

The existing capacities of both Lakeview Water Pollution Control Plant and R.L. Clark filtration plant (See Figure 1) are to be increased as part of the Peel County Municipal Service Scheme. In addition to the above outfall and water intake, the other water users in the region are the cooling water intake of Lakeview Generating Station, South Peel Water intake, proposed development of the recreational facilities (east of the mouth of Etobicoke Creek), fishery and in particular spawning of Cyprinus Carpio Linneons at the mouth of Etobicoke Creek. As the Lakeview area proposed for the outfall is a region of intense water use, a knowledge of the local water movement and dispersion characteristics was considered necessary to ascertain the possible effects of increased loadings on all water users of the area.

The problem is to locate the outfall such that it would have the least impact on the other users with priority being given to the municipal water supply intakes. As the nearshore lake dynamics can be somewhat random with respect to time, it was decided to collect water movement data at various locations both offshore and along the shore for an extended time period. Statistics (time series and cross

correlations) would then be available to indicate differences and similarities between locations, percentage of the time when zero or negligibly small currents exist, correlations with wind, predominate current directions if they exist and the occurrences of high velocity movements in undesirable directions. The fixed point measurements thus provide valuable time statistics on the current variations but not on the spatial variation or the local velocity field. Estimates of velocity field were obtained by cross correlating current histories at two different points. If a statistically significant correlation existed at many time periods, it was assumed that the region between the two meters was also correlated and dispersion predictions were made in this region utilizing the data collected at a fixed point. A few continuous constant rate fixed point dye injection studies were conducted to check the dispersion predictions.

Total coliforms and free ammonia concentrations (of raw water) are measured regularly at the R.L. Clark filtration plant. These analyses were compared to concurrent measurements of current to determine if high values are associated with a predominant water movement direction.

On the basis of these measurements, a location with the most favourable water movement statistics was selected for the outfall and an appropriate diffuser designed to achieve the desired initial dilution.

2.0 METHOD

2.1 Physics

Recording current instruments were operated at four different locations (041, 043, 047 and 049) on fixed towers resting on the bottom as follows (Figure 1):

Location	Instrument Elevation from Bottom m	Mean Water Depth m	Period of Operation
041	3.0	9.5	May 21 - Dec 10, 1970
043	3.0	9.5	May 21 - Dec 10, 1970 Dec 9 - Mar 27, 1972
047	3.0	9.5	Dec 21 - Mar 27, 1972
049	3.4	13.7	Dec 8 - Mar 31, 1972 June 2 - Jul 17, 1972

These instruments were set to record current magnitude (averaged over 10 to 20 minutes - see Table 1), direction and temperature every 10 to 20 minutes. The instruments were laboratory calibrated in tow tanks before and after operations and checked in the field by other measuring techniques (drogue trackings and telethermometers). The field drogue measurements were conducted in proximity of each location to ensure proper instrument operation (Appendix 1).

During June and July, 1970, the measurements at 043 were also compared with data recorded independently at the same time by an instrument operated by the Canada Centre for Inland Waters (CCIW) at Location 045 (Figure 1) on a submerged buoy support system.

2.2 Chemical and Bacteriological Parameters

Raw water samples from the R.L. Clark water intake were analyzed by the filtration laboratory staff according to Standard Methods (APHA, 1965). Free ammonia was analyzed every two hours during the period of study and total coliforms were examined four times daily (every six hours) during working days. The frequency of analysis was reduced during weekends and holidays to two or three each day.

3.0 DATA ANALYSIS

3.1 Physics

The data were processed for each instrument location to obtain a statistical summary by months. Current measurements not comparing favourably with the appropriate drogue tracking were rejected. Some frequency tables appear in Appendix II which have been summarized in Table 1. Terms appearing in the frequency tables (statistical summary) were defined and computed as follows:

1. Mean current is the arithmetic average of all current speeds independent of direction.
2. Resultant current is the equivalent vector which locates a particle released at the meter due to transportation by the measured monthly current history.
3. The persistence factor (P) is defined as the ratio of magnitudes of resultant current to the mean current (Panofsky, 1968). "P" must lie between 0 and 1 such that $1 \geq P \geq 0$. P = 1.0 when currents flow from the same direction for the entire monthly period and P = 0.0 when currents are equally from all or vectorally opposed directions such that there is no resultant water transport away from the meter locations.

Current frequency roses were plotted (Figure 2) and are interpreted as follows. The thickness of the line represents a group of speeds (e.g. 0.31 to 5.99 cm/sec) and the length of the line is proportional to the probability of the particular speed group occurring in that direction. The current directions, in this case, are going away from the instrument location. Water movement directions at all locations considered, are similar, predominantly moving along northeast and southwest axis parallel to the shoreline.

Both current and wind data were prewhitened using binomial weighting factors and subjected to time series analysis to determine autospectra (Tables 2 and 3) and coherence spectra for currents at different locations (Tables 4 and 5) and currents and winds (Table 6). The spectra were determined on hourly mean values using standard numerical techniques with a Hanning of the coefficients. A summary of the statistically significant periods at a 5 percent level of confidence are listed in Tables 2-6.

As water movements from location 043 towards R.L. Clark intake occurred frequently during Sep 70, Nov 70, Dec 71, Jan 72 and Feb 72, hourly mean distances were computed using a Markov chain technique (stochastic process) for currents from the southwest. Table 7 gives an idea of the average and maximum distances travelled by a particle released at 043 during the monthly period under consideration using a progressive vector plot. It is observed that excursions are about one km

away from the R.L. Clark intake, its movement would continue in that direction. On a probability basis, the particle would be approximately 500 and 1,200 m closer to the shore than to the intake after 30 and 15 hr in Sep 70 and Nov 70 (Figure 3). As these are estimates based on a homogeneous velocity field which is only an estimate over these distances, the 500 m separation would probably have some influence on the intake.

The frequency (of occurrence) of water temperature was determined and presented in Table 8 with computed monthly mean and standard deviations for each location. The first temperature range of 0.0 - 3.99 C in the frequency table is obviously not satisfactory for winter conditions between December and March; however, the monthly means and standard deviations for these months are meaningful.

3.2 Two-Dimension Dispersion Computations

Dispersion estimates from recording current meter data at a fixed point assumes that the velocity field is spatially homogeneous with the Eulerian measurements reasonably approximating the Lagrangian. These assumptions can be justified to some extent statistically with cross correlations; however, it is known that spatial homogeneity does not prevail and estimates of this type are approximate.

The time sequence of current measurements was processed by and subjected to transition probability techniques (Markov Chain, where the time sequence of measured currents is maintained) to determine hourly two-dimensional estimates (Palmer and Izatt, 1970). A plot of the

successive hourly patterns appear in Figure 4 for location and the initial state indicated. The areas defined by the related hourly contours represent a measure of dispersion and NOT the actual expected plume. The two-dimensional dispersion estimates appear in Table 9. In addition to the above prediction method, dispersion contours based on weighted current velocity from the frequency table for five hours are plotted with the results of a constant rate dye injection experiment (Figure 5). The dye experiment does not agree with the dispersion contours based on current statistics. However, the transition probability matrix with the appropriate initial current vector contours based on a whole months record appear generally in better agreement with an experimental result on one particular day of the month (see contours as well as predicted concentrations).

One-dimensional dispersion (for 5 hours) was also computed for the major compass directions utilizing the Markov chain techniques (Palmer and Izatt, 1971) to compare directional dispersion differences. For any particular month and meter location it is possible to read the direction of minimum or maximum dispersion from Table 10. Five hourly mean distances in north and south directions are plotted in Figure 2 for each location and period and then joined by two smooth curves generating a "dispersion band". It is noted that dispersion in east and west directions lie within this "band".

In the near shore regions of the Great Lakes, one-dimensional dispersion characteristics are the largest in directions parallel to the shore and smallest in the offshore direction. Consequently, material discharged in

these regions tend to be confined to the near shore areas and spread parallel to the shoreline. Current data collected at all locations and periods exhibited these properties; however, the short term dispersion at location 043 for Jun 70, Jul 70, Aug 70 and Mar 72 was larger in the offshore direction. This characteristic is confirmed by the monthly resultant currents for 043 in Figure 1.

3.3 Chemical and Bacteriological Analysis

Free ammonia concentrations greater than 0.02 mg/litre and total coliforms greater than 300 counts/100 ml were tabulated with concurrent measurements of current speed and direction at 043 (see Appendix III). The currents were resolved in the four major compass directions revealing a predominance along a northeast and southwest axis, i.e. parallel to the shoreline as expected in the near shore regions. Bonde and Thomsen (1971) compared Escherichia coli counts (approximately equivalent to fecal coliform) with meteorological and current measurements utilizing Chi-square tests and multivariant analyses. They found linear dependence of E coli on wind, currents, season and location utilizing selective grouping of the data.

The number of occurrences of free ammonia concentrations and total coliform counts in the three arbitrarily selected categories, each category associated with one of two predominant directions (northeast and southwest), are presented in Table 11. The arbitrary categories chosen were:

Free ammonia: (i) 0.02 - 0.04,

(ii) 0.04 - 0.06, and

(iii) 0.06 mg/l.

Coliform: (i) 300 - 600,

(ii) 600 - 900, and

(iii) 900 counts/100 ml.

The frequency of occurrence in these categories with current direction appearing in Table 11 were subjected to Chi-squared tests (Bowker and Lieberman, 1959, p. 366) for each parameter for two directions and three categories. The results of the tests are presented in Table 13. High values of free ammonia as well as total coliform counts were found to occur as a series of consecutive readings over a period of time. As current patterns normally persist in one direction for many hours at a time, it was considered that the high free ammonia and coliform counts persisted during the same prevailing current condition. Consequently, the numbers of groups of readings in each category should be used in the statistical testings instead of the individual readings which may bias the results during a long period of persistent current pattern. Accordingly, the predominant direction of the current for each group was then determined (Table 12). Northeast and southwest group frequencies were then subjected to Chi-square tests (Table 13). Total coliform data for 1972 revealed very low counts. During the four months from December 1971 to March 1972, counts greater than 300/100 ml occurred only seven times. Consequently, these data were not included in the tests.

4.0 DISCUSSION

4.1 Water Transport

The summary of the measured water movement at five locations is presented in Table 1. Monthly resultant currents varied from 0.3 to 5.4 cm/sec with persistence factors of 0.09 to 0.79. The maximum monthly speeds ranged from 12.8 to 43.7 cm/sec. These results compare favourably with other near shore studies. In Lake Ontario, Hamblin and Rogers (1967) obtained resultants of 1.7 to 4.3 cm/sec and Palmer and Kohli (1972) obtained resultants of 0.2 to 5.0 cm/sec with persistence factors of 0.07 to 0.75 in similar near shore areas of Nanticoke in Lake Erie.

The resultant currents at the location of the proposed outfall (043) were into the lake and away from all water users for 5 periods out of 10 periods studied. For the remaining 5 periods, the resultant currents were going towards the R.L. Clark intake. No detectable currents varied from 8 to 38 percent of the month while the currents moved towards R.L. Clark intake for 5 to 13 percent of time during periods of resultant movement away from all water users. Persistence factors at location 043 varied from 0.10 to 0.72. The maximum persistence factor of 0.72 was associated with the maximum resultant velocity of 5.4 cm/sec towards the R.L. Clark intake during Jan 72 and small values of dispersion coefficients (0.15 to 0.97 m^2/sec). Therefore, Jan 72 was the worst period studied at location 043 for

water movement characteristics with regard to the R.L. Clark intake. During Jan 72, thirteen periods of one or two days duration exist at location 043 when average velocities were 5 to 25 cm/sec towards the R.L. Clark intake. However, for this period and location, the average velocity towards the R.L. Clark intake was 10 cm/sec. If a particle were released at location 043, it would take about 30 hr to reach the vicinity of the intake; but it would be about one km closer to shore than the intake on a probability basis.

The free oscillation period of 5.4 hours for Lake Ontario (Hamblin, 1968) appears in the auto energy spectra (Table 2) although its presence is not apparent at the 5 percent significance level for all monthly periods.

The coherence spectra (Table 4) for currents at 043 and 045 have many significant concentrations at periods less than 15 hours in the east-west direction indicating an along shore correlation over a distance of 1.3 km. This provides some validation to estimating dispersion from current records at least parallel to the shore.

An outfall location should be a region with an active water movement (small periods of zero velocity) and where water movements towards known intakes are not frequent. Table 1 shows there is little to choose between all the locations examined as they are all active regions except for near shore locations 041 and 049, (the only location to the east of the R.L. Clark intake). Location 043 is the best from dispersion considerations as it is geographically the

farthest from existing water intakes thereby permitting the longest time for dispersion.

While monthly resultant currents can be misleading for a predominantly two directional velocity field, it can be clarified by examining the percentage of the record when current moves in the resultant direction (Table 1). Location 043 does have some periods when the resultant is favourably in an offshore direction. This occurs most frequently at 043 making it more desirable than the other locations.

4.2 Wind

The concurrent hourly wind data were obtained from the Atmospheric Environment office for Toronto Island Station. A typical example of the two-dimensional frequency (of occurrence) table is presented in Appendix II. Persistence factors were generally low except for Jan 72 when the factor was 0.69. This is in general agreement with the water movement records at location 043. Both the wind and currents moved towards the R.L. Clark with high persistence factors during Jan 72. Cross-correlations of wind with current at location 043 have revealed significant coherences at periods in both north-south and east-west directions (Table 6). This indicates that currents are related to winds for the period 2.1 to 17.1 hr. In other words, the effect of wind on current (at depth of meter location) would be felt after 2.1 hr to 17.1 hr.

4.3 Water Temperature

It is observed from the temperature frequency, Table 8, that the temperature variations were 0.7 C to 23 C. The maximum monthly temperature variation of 18 C occurred at location 045 during Jul 70 indicating that the currents during this period may have been related to thermal densities.

4.4 Dispersion and Dilution

The estimated 5-hour dispersion coefficients (Table 10) vary from 0.0 to 6.5 m^2/sec. These coefficients compare favourably with other studies (Csanady, 1964; Noble, 1961; Okubo, 1967; Palmer and Izatt, 1970) in the near shore regions of Great Lakes (Table 14).

Although the resultant currents at location 043 moved towards the R.L. Clark intake during Sep 70, Nov 70, Dec 71, Jan 72 and Feb 72, the spatial separation between these two locations provide dilution factors of 0.025 to 0.0134 during Nov 70 and Jan 72 (see Table 7 for details) ignoring the densities of an effluent and assuming area to be dynamically homogeneous (these are the worst periods when currents moved towards the intake with lower dispersion coefficients). With the above dilution factors, the effluent discharged at location 043 should not adversely affect the water quality at the intakes provided the effluent is of reasonable quality. The computations for dilution factors did not consider a diffuser discharge and were based upon current measurements at the mid-depth.

If a multiport diffuser (Appendix IV) is incorporated, the dilution factors to the top of the rising column from a 2 foot port, may be computed as 0.028 (after Rawn et al, 1961). The density difference between the effluent and the lake water would also cause further dilution due to horizontal spreading (Larsen, 1968). At the R.L. Clark intake, the dilution factors due to density difference, as well as combined with those due to buoyant jet rise, are presented in Table 15.

A schematic diagram showing the jet rise and horizontal spreading on the lake surface appears in Figure 6. The horizontal spreading will occur at the maximum rise of jet, which may not always be the lake water surface due the prevailing stratification.

The combined dilution factors (Table 15) due to buoyant jet rise and horizontal spreading, will further be complemented by dilution factors due to dispersion (Table 7).

4.5 Chemical and Bacteriological Data

The results of the Chi-square tests (Table 13) indicate that the high free ammonia measurements (at R.L. Clark intake) were not associated with the concurrent water movements at location 043 during 1970 and 1972 at confidence levels of 20 to 80 percent. Palmer (1972) found the lack of significant relationships between currents and water chemistry parameters on an hourly basis (both concurrently recorded at 043) and attributed this to the very small magnitudes of currents with the arithmetic averages of 3.5 to 6.0 cm/sec and/or

rapidly varying velocity fields. However, Palmer (1972) found some significant relations for time periods greater than 15 hr. Palmer observed that "a knowledge of currents only is inadequate to explain lake shore chemistry time distribution"; consequently, the augmentation of the current measurements with chemical or bacteriological data is important. Therefore, it is not surprising to find no significant relationship between currents (at location 043) and high free ammonia at R.L. Clark intake. Chi-square test results (Table 13) reveal that the high total coliform counts (R.L. Clark intake) during 1970 were associated with concurrent water movements (at location 043) towards the southwest direction at a 98 percent confidence level for grouped readings. Bonde and Thomsen (1971) also found linear relationship between E coli and current and wind direction.

4.6 Special Considerations

A buoyant effluent would reduce dilution. A diffuser system should reduce buoyancy effects of the discharge, as buoyancy is likely to occur particularly during upwelling periods (which frequently occur in this area during July and August). Once the effluent reaches the surface, the dilution achieved will be less and the plume will become visible. Initial mixing from the properly designed multiport diffuser jets normally increase dilution of an effluent over the point of discharge by a factor of 4 to 10, depending upon the size of outfall and diffuser jets (Rawn et al, 1961). The greater the number of jets, the smaller

will be the size of each port, the better the initial mixing occurring. The flow should remain full through all ports under all conditions of flow without hydraulic loss. Rawn's (1961) small scale model studies of the multiport diffuser system has confirmed the theoretical predictions of their superiority over other systems. The orientation of the diffuser jets should be such that the predominant currents intercept the effluent (approximately 140° from the north, in this case) thereby, entraining lake water into the discharge field and consequent dilution of the effluents.

A suitable multiport diffuser can be designed in many ways to meet the flow and hydraulic conditions. One such simple design is included in Appendix IV for reference.

5.0 CONCLUSIONS

5.1 Water Movements

The results of the present study reveal water movement and dispersion characteristics in this area to be of the same order of magnitude as in the other near shore areas of Lake Ontario. Among the locations studied for the proposed outfall, location 043 was considered the best overall site.

Location 043 is the best among those considered due to favourable water movements during five of the ten monthly periods studied, spatial separation between 043 and both R.L. Clark and South Peel intakes, favourable dispersion characteristics, significant association of coliforms at R.L. Clark intake with water movements at location 043 going towards southwest. During ten periods studied at location 043, periods of no detectable currents varied from 8 to 38 percent with the arithmetic mean currents varying from 2.30 to 7.51 cm/sec. This indicates reasonable water movement in the area.

5.2 Effects on Water Uses in the Area

If the proposed outfall is located at 043, its spatial separation from both municipal water intakes in the area (R.L. Clark and South Peel) together with water movements and dispersion characteristics, will ensure that water quality at either intake is not impaired.

A particle released at location 043 has little chance of reaching the cooling water intake at Lakeview Generating Station.

Thus, an outfall at location 043 will have no affect on water quality at the cooling water intake.

As the currents at location 043 never moved towards the shore or Etobicoke Creek (see Figure 1), an outfall at location 043 will have very little affect on water quality in the proposed landfill area east of Etobicoke Creek designated for recreational uses. For the same reasons, spawning of Cyprinus Carpio Linnoeus in the creek will not be disturbed due to the proposed outfall.

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TABLE 1

Summary of Current Meter Results

Period	Jun 70			Jul 70			Aug 70	Sep 70	
Location	041	043	045	041	043	045	043	041	043
Resultant speed (cm/sec)	1.17	1.38	0.53	0.50	0.34	0.57	1.24	3.39	1.06
Resultant Direction coming from (degrees)	145	20	90	135	289	72	356	51	240
Period of Zero Velocity (% of recording period)	21	14	17	36	25	5	8	24	15
Average speed (cm/sec)	3.60	3.49	2.98	2.26	2.30	3.44	5.39	3.61	4.36
Max. speed (cm/sec)	18.91	20.49	14.58	18.85	13.83	21.13	20.16	18.64	19.78
Persistence	0.32	0.39	0.18	0.22	0.15	0.16	0.23	0.94	0.24
Total no. of readings (interval in minutes)	4320 (10)	4312 (10)	2159 (20)	4458 (10)	4007 (10)	2232 (20)	4461 (10)	4320 (10)	4311 (10)
Percentage of time going in resultant direction	7	4	4	3	2	5	4	38	12
Percentage of time going towards R L Clark Intake	5*	5	3	7*	10	3	6	1*	12

*towards South Peel intake

TABLE 1 (cont'd)

Summary of Current Meter Results

Period	Oct 70	Nov 70	Dec 71			Jan 72		
Location	043	043	043	047	049	043	047	049
Resultant speed (cm/sec)	0.83	2.31	1.81	0.64	0.74	5.43	2.19	4.44
Resultant Direction coming from (degrees)	9	248	242	134	137	236	199	60
Period of Zero Velocity (% of recording period)	10	8	7	27	27	9	15	24
Average speed (cm/sec)	4.26	6.06	6.91	3.06	7.79	7.51	3.84	7.72
Max. speed (cm/sec)	17.05	27.48	34.41	26.36	36.96	29.39	16.33	36.48
Persistence	0.19	0.38	0.26	0.21	0.09	0.72	0.57	0.58
Total no. of readings (interval in minutes)	4464 (10)	4317 (10)	1584 (20)	717 (20)	2208 (15)	2232 (20)	2228 (20)	2976 (15)
Percentage of time going in resultant direction	1	13	23	2	3	41	8	28
Percentage of time going towards R L Clark Intake	13	25	23	1	8	41	2	14

TABLE 1 (cont'd)

Summary of Current Meter Results

Period	Feb 72			Mar 72			Jun 72	Jul 72
Location	043	047	049	043	047	049	049	049
Resultant speed (cm/sec)	0.44	0.64	0.68	1.24	0.46	2.43	3.84	1.08
Resultant Direction coming from (degrees)	237	121	270	43	57	238	26	234
Period of Zero Velocity (% of recording period)	32	18	23	38	26	45	0	1
Average speed (cm/sec)	4.55	2.89	7.17	3.62	2.31	6.45	4.86	3.35
Max. Speed (cm/sec)	24.07	12.81	43.74	28.98	14.20	40.02	15.99	13.61
Persistence	0.10	0.23	0.10	0.34	0.20	0.38	0.79	0.32
Total no. of readings (interval in minutes)	2088 (20)	2088 (20)	2784 (15)	1986 (20)	1842 (20)	2976 (15)	2688 (15)	1574 (15)
Percentage of time going in resultant direction	18	1	5	19	9	18	11	7
Percentage of time going towards R.L Clark Intake	18	1	7	12	1	6	6	5

TABLE 2

SUMMARY OF MAJOR SPECTRAL PERIODS (HOURS)

AUTO SPECTRA OF CURRENTS

Location and Period	Currents	
	North-South	East-West
043 Jun 70	17.1, 7.5	24.0, 10.0
043 Jul 70		
043 Dec 71	None	None
043 Jan 72	None	None
043 Feb 72	8.0	15.0
043 Mar 72	10.9, 4.8	5.5
045 Jun 70	15.0	15.0
045 Jul 70	17.1, 7.1	20.0, 8.0
047 Dec 71	None	None
047 Jan 72	8.0	8.0
047 Feb 72	13.3, 10.0	10.9, 8.6
047 Mar 72	10.9, 5.0 - 3.5	6.3, 3.1
049 Dec 71	10.9, 5.2 - 2.7	6.0, 4.8, 2.6
049 Jan 72	10.0, 4.8 - 2.6	7.1, 4.6 - 2.3, 2.3
049 Feb 72	8.6, 4.0 - 2.1	15.0, 5.0, 3.1, 2.7
049 Mar 72	8.6, 4.4 - 2.1	12.0, 5.5 - 2.9 2.7, 2.5 - 2.1

TABLE 3

SUMMARY OF MAJOR SPECTRAL PERIODS (HOURS)

AUTO SPECTRA OF WIND AND WATER LEVELS

Period	Wind		Water Levels
	North-South	East-West	
Jun 70	None	None	None
Jul 70	13.3	None	None
Dec 71	None	None	None
Jan 72	None	None	None
Feb 72	13.3, 9.2, 7.5, 6.0, 4.8	7.5	10.9, 5.5
Mar 72	10.9, 5.5	10.0	12.0, 8.0, 4.6

TABLE 4

SUMMARY OF COHERENCES

CROSS CORRELATIONS OF CURRENTS

AT 043 and 045

Period	Periods with significant 5% Coherences (hours) Currents	
	North-South	East-West
Jun 70	None	5.7, 4, 3.1
Jul 70	None	15.0, 13.3, 6.7, 4.6

TABLE 5

Summary of Coherences

Cross Correlations of Currents

at Locations 043 & 047

	Periods with Significant 5% Coherences (hours)	
	North-South	East-West
Dec 71	12	12
Jan 72	20	None
Feb 72	24, 13	None
Mar 72	15, 12	None

TABLE 6

SUMMARY OF COHERENCES

CROSS CORRELATIONS BETWEEN WIND AND CURRENT

AT LOCATION 043

Location and Period	Periods with Significant 5% Coherences (hours)	
	North-South	East-West
043 Dec 71	10.5	None
043 Jan 72	3.4, 2.7, 2.1	3.8, 2.7
043 Feb 72	4.3, 2.1	10.0, 2.4, 2.2
043 Mar 72	17.1, 2.3	5.8
047 Dec 71	20.0,15.0, 6.3	24.0, 9.2-6.0
047 Jan 72	None	None
047 Feb 72	4.6	None
047 Mar 72	10.9	None

TABLE 7

Some Characteristics at Location 043 during Unfavourable Periods

Period	Average Speed	Average Period	Maximum Period	Average Distance	Maximum Distance	Dilution Factor at Intake due to Dispersion Only	Total Dilution Factor at Intake	
	cm/sec	hr	hr	km	km		Flow= 689 cfs	Flow= 279 cfs
Sep 70	6.0	6.0	30.0	1.30	6.48	0.0042	.000011	.000100
Nov 70	9.0	15.0	60.0	4.86	19.44	0.0025	.000063	.000060
Dec 71	8.71	24.2	53.0	7.59	16.62	0.0026	.000065	.000062
Jan 72	9.85	31.8	83.0	11.28	29.43	0.0134	.000336	.000321
Feb 72	7.37	21.0	59.0	5.57	15.65	0.0033	.000083	.000079

TABLE 8

TEMPERATURE FREQUENCY

TEMPERATURE RANGE °C	JUNE 1970			JULY 1970			AUGUST 1970	SEPTEMBER 1970		OCTOBER 1970	NOVEMBER 1970	DECEMBER 1971		JANUARY 1972		FEBRUARY 1972		MARCH 1972	
	041	043	045	041.	043	045	043	041	043	043	043	043	047	043	047	043	047	043	047
0.0 - 3.99												52.76	83.54	99.06	97.44	99.86	98.42	100.0	99.35
4.0 - 4.99			0.84								1.70	41.52	16.46	0.94	2.56	0.14	1.58		0.65
5.0 - 5.99	3.95	6.01	20.82		0.30	3.93				3.66	17.71	5.71							
6.0 - 6.99	9.03	18.74	14.35	2.87	6.20	11.92		4.67	1.27	15.88	6.94								
7.0 - 7.99	9.87	6.15	14.77	3.69	6.51	10.70		1.42	3.25	3.93	1.27								
8.0 - 8.99	18.05	16.36	20.53	4.51	11.35	12.06		2.97	3.54	5.83	6.60								
9.0 - 9.99	21.58	21.26	10.41	11.20	17.25	5.83	1.36	5.24	5.23	2.44	19.55								
10.0 - 10.99	12.98	10.77	1.83	12.02	11.95	5.56	6.65	4.25	6.08	1.76	19.26								
11.0 - 11.99	4.37	1.12	0.84	9.56	12.71	7.76	6.11	5.81	17.26	33.79	26.77								
12.0 - 12.99	1.27	0.70	2.25	14.07	11.65	6.37	11.67	16.01	7.50	32.70									
13.0 - 13.99	7.76	18.88	3.94	8.33	4.24	6.37	15.20	3.40	10.04										
14.0 - 14.99	10.72		5.91	9.70	13.92	3.25	14.38	23.37	11.60										
15.0 - 15.99	0.42		3.52	15.57	3.78	8.81	14.65	14.87	24.89										
16.0 - 16.99				7.10	0.15	1.36	5.70	2.41	9.34										
17.0 - 17.99				1.09		0.81	3.26												
18.0 - 18.99				0.27		2.30	3.53												
19.0 - 19.99						3.25	8.14												
20.0 - 20.99						5.15	9.36												
21.0 - 21.99						4.07													
22.0 - 22.99						0.54													
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
MONTHLY MEAN	9.83	9.25	8.49	12.38	10.87	11.82	15.04	13.43	13.08	10.40	9.18	3.94	3.56	2.11	2.46	1.37	1.85	0.85	1.33
STANDARD DEVIATION	2.55	2.51	2.87	2.73	2.40	4.70	2.96	2.81	2.50	2.40	2.29	0.74	0.47	0.67	0.67	0.68	0.72	0.43	0.47

TABLE 9

Dispersion Coefficients for Lakeview (Lake Ontario)

ε m^2/sec

Location Code	2 Hours	4 Hours	6 Hours	8 Hours
041 Jun 70**	0.15	1.78	2.37	3.04
043 Jun 70	0.87	1.65	2.27	2.81
045 Jun 70	0.42	0.83	1.16	1.43
041 Jul 70	0.74	0.91	1.09	1.23
043 Jul 70	0.27	1.02	1.45	1.70
045 Jul 70	1.6	1.03	1.49	1.65
043 Aug 70	0.79	1.54	2.15	2.69
041 Sep 70	0.67	0.99	1.15	1.24
043 Sep 70	0.14	0.39	0.58	0.82
043 Oct 70	0.06	0.24	0.43	0.64
043 Dec 71	0.14	0.43	0.64	0.82
047 Dec 71	0.26	0.58	1.37	2.30
049 Dec 71	0.39	0.96	1.53	2.12
043 Jan 72	0.15	0.31	0.71	0.97
047 Jan 72	0.58	2.02	3.67	4.45*
049 Jan 72	0.36	0.63	1.08	1.54
043 Feb 72	0.07	0.11	0.21	0.25
047 Feb 72	0.26	0.50	0.50	0.68*
049 Feb 72	2.18	4.38	6.96	9.41
043 Mar 72	0.14	0.26	0.35	0.51
047 Mar 72	0.09	0.24	0.42	0.56
049 Mar 72	0.36	0.87	1.34	2.10

* 7 Hour Dispersion

**041 Jun 70 means location 041 and period June 1970

TABLE 10

Summary of 5 Hour Dispersion Co-efficients

Location	Direction from	Maximum	Minimum	Mean	Std. Dev.
		m^2/sec	m^2/sec	m^2/sec	m^2/sec
041	North	2.830	0.030	0.986	1.597
	East	3.898	0.660	1.751	1.859
	South	0.535	0.001	0.228	0.275
	West	0.578	0.000	0.303	0.290
043	North	0.987	0.003	0.607	0.371
	East	1.790	0.150	0.776	0.470
	South	2.981	0.003	0.592	0.916
	West	4.229	0.110	1.002	1.344
045	North	0.574	0.257	0.415	0.224
	East	0.639	0.333	0.486	0.216
	South	0.679	0.237	0.458	0.312
	West	0.117	0.061	0.089	0.039
047	North	0.263	0.000	0.086	0.096
	East	0.182	0.033	0.088	0.064
	South	1.180	0.035	0.516	0.560
	West	0.367	0.019	0.206	0.181
049	North	1.624	0.096	0.608	0.687
	East	6.540	0.663	2.836	2.571
	South	2.350	0.084	0.815	1.069
	West	3.339	0.270	2.178	1.381

TABLE 11

Frequency of Occurrences (Categories)
(Directions going to)

Coliform Range	300-600		600-900		> 900	
Free Ammonia Range	0.02-0.04		0.04-0.06		> 0.06	
	N&E	S&W	N&E	S&W	N&E	S&W
Coliforms (Std. Plate Count) Jun-Nov 1970	35	51	10	14	18	39
Free Ammonia (mg/1) Jun-Nov 1970	23	34	2	5	3	9
Free Ammonia (mg/1) Dec 71-Mar 72	104	96	32	43	72	55

TABLE 12

Group Frequencies

Directions (Going to)	Group Frequency		
	Total Coliforms (Std. Plate Count) Jun-Nov 1970	Free Ammonia (mg/1)	
		Jun-Nov 1970	Dec 1971-Mar 1972
N & E	19	12	29
S & W	37	21	31
N & W	7	5	0
S & E	4	0	1
E	3	0	1
S	2	0	0
NIL	4	6	9

TABLE 13

Testing for Differences by Current Directions

	Total Coliforms (per 100 ml) Jun-Nov 1970		Free Ammonia (mg/l) Jun-Nov 1970		Free Ammonia (mg/l) Dec 71-Mar 72	
	Grouped Readings	Individual Readings	Grouped Readings	Individual Readings	Grouped Readings	Individual Readings
χ^2	5.79	11.93	2.41	6.35	0.067	4.23
Degrees of Freedom (η)	1	5	1	5	1	5
% Level of Significance	0.02	0.05	0.20	0.30	0.80	0.70
$\chi^2_{\alpha,\eta}$	5.41	11.07	1.64	6.06	0.064	3.0

TABLE 14

RESULTS OF OTHER STUDIES

Reference		ε m^2/sec
Palmer & Izatt	(1970)	0.067 - 17.4
Csanady	(1964)	0.04 - 0.2
Okubo	(1967)	3.0 - 6.0
Noble	(1961)	0.0244

TABLE 15

Dilution Factors at R. L. Clark Intake

Flow Condition	Due to Jet Rise	Due to horizontal spread	Due to (1) and (2)
	(1)	(2)	(3)
Peak Flow=687 cfs	0.02857	0.87842	0.02509
Average Flow=279 cfs	0.02857	0.83938	0.02398

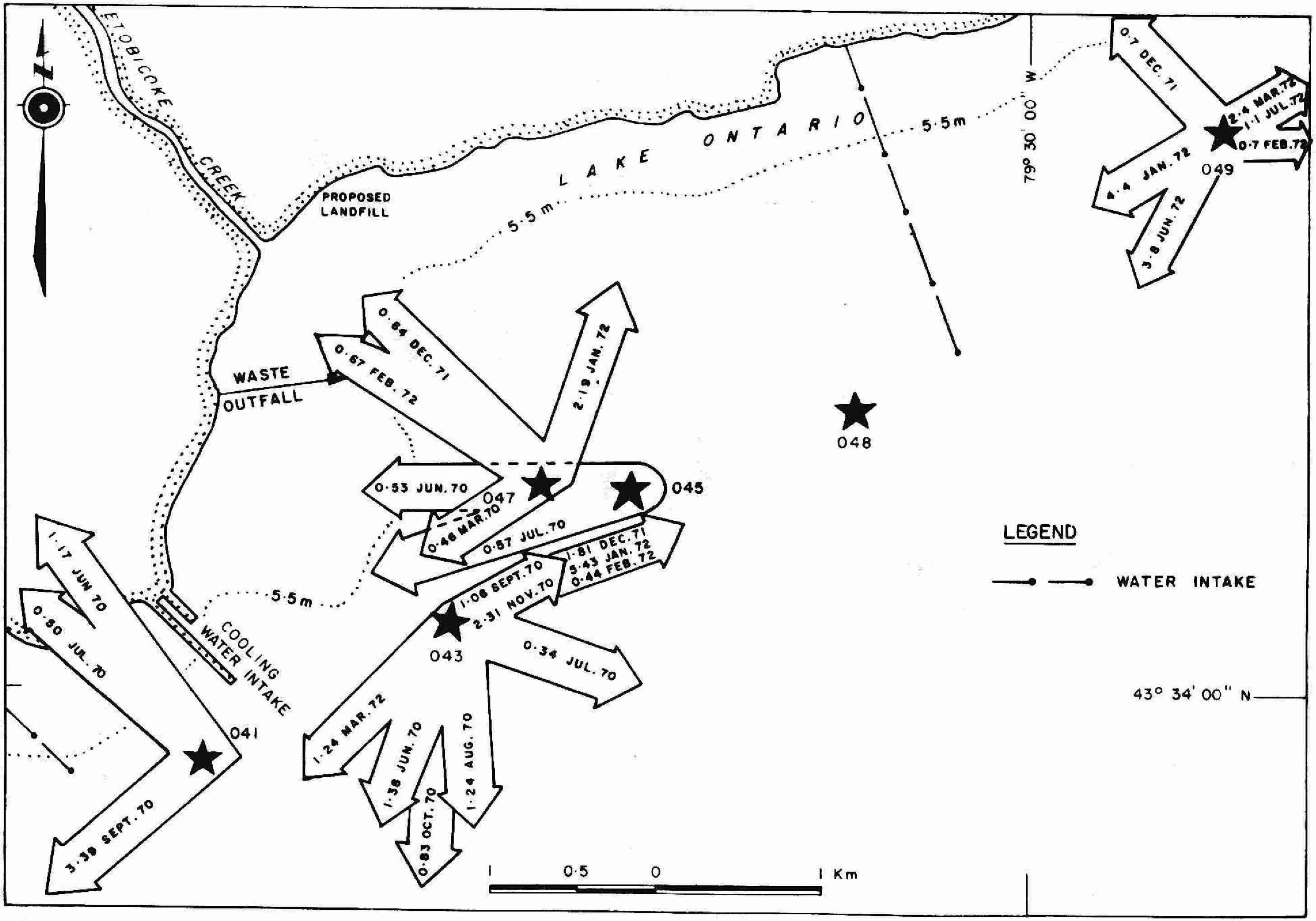

Fig. 1   Resultant currents

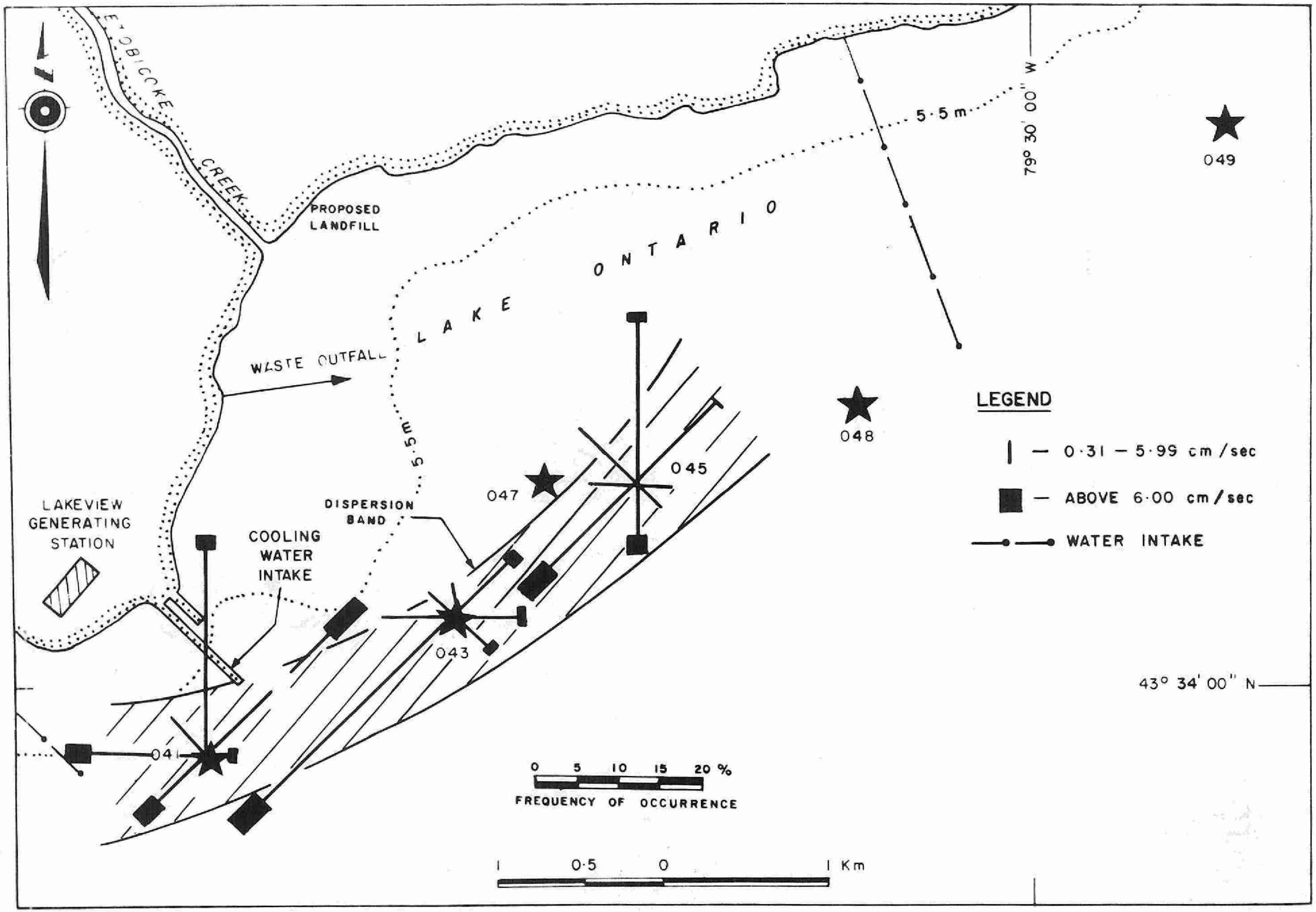

Fig. 2 Current frequency roses - June 1970

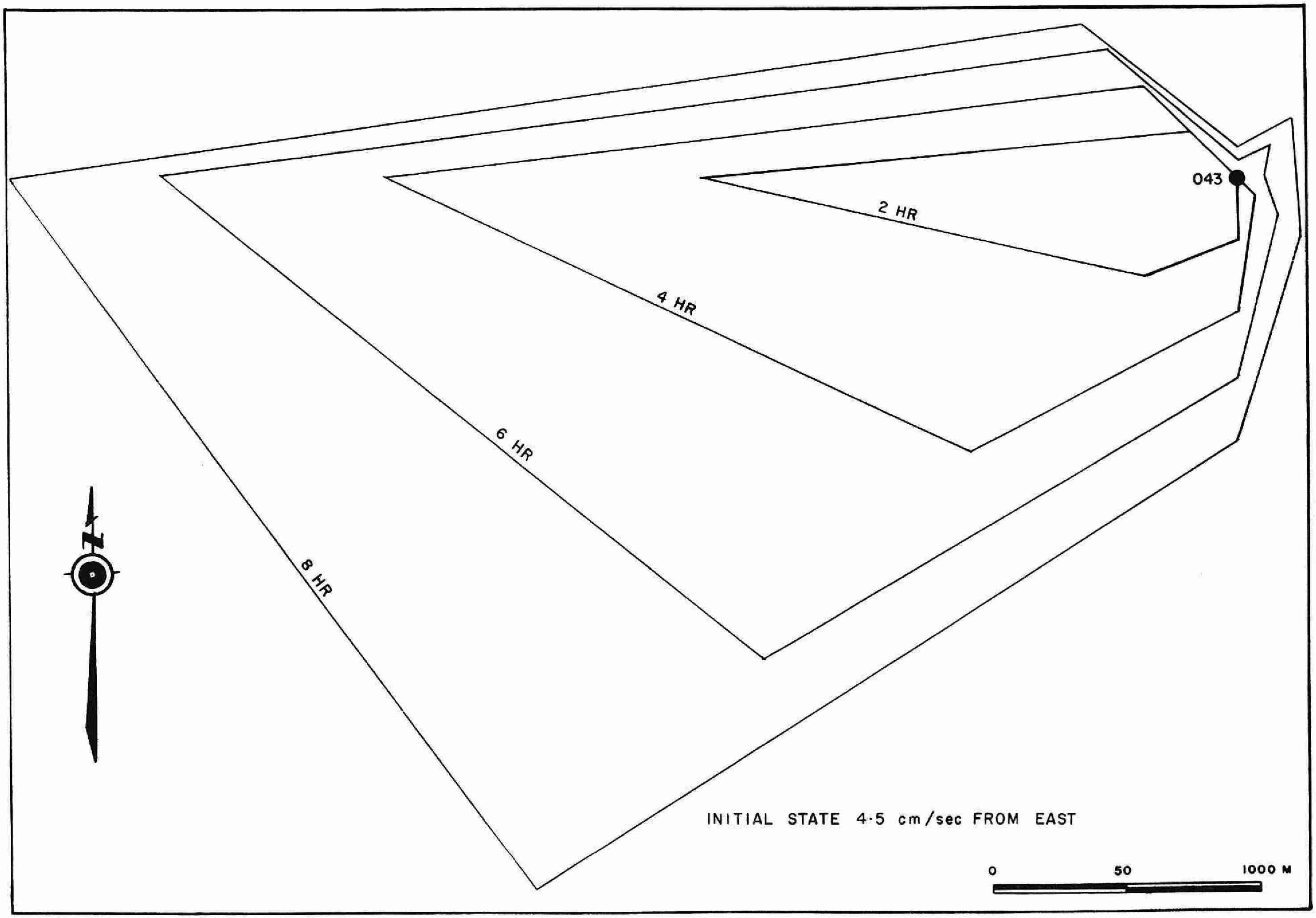

Fig. 3 Hourly dispersions - June 1970

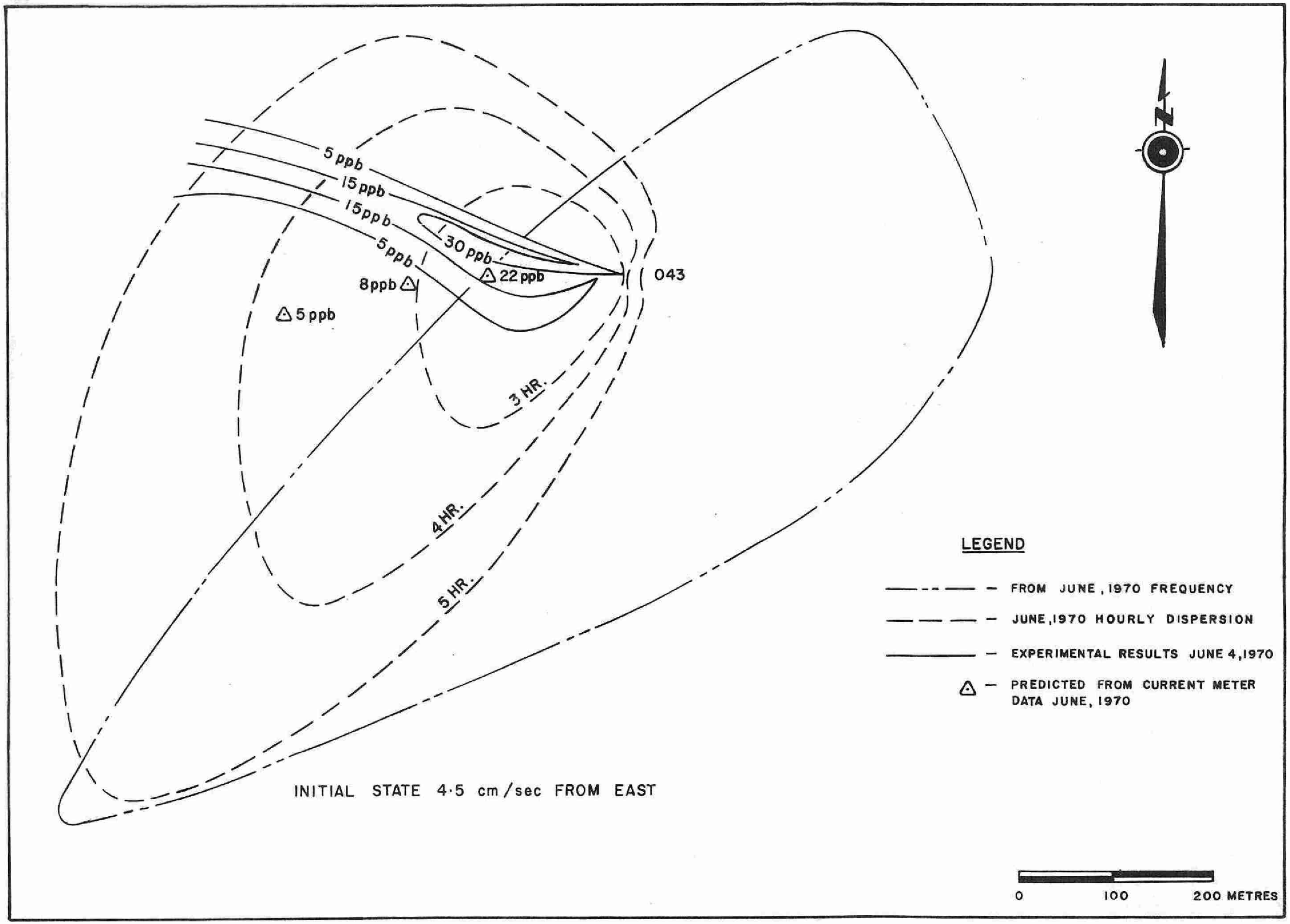

Fig. 4 Comparison of dispersion at Location 043

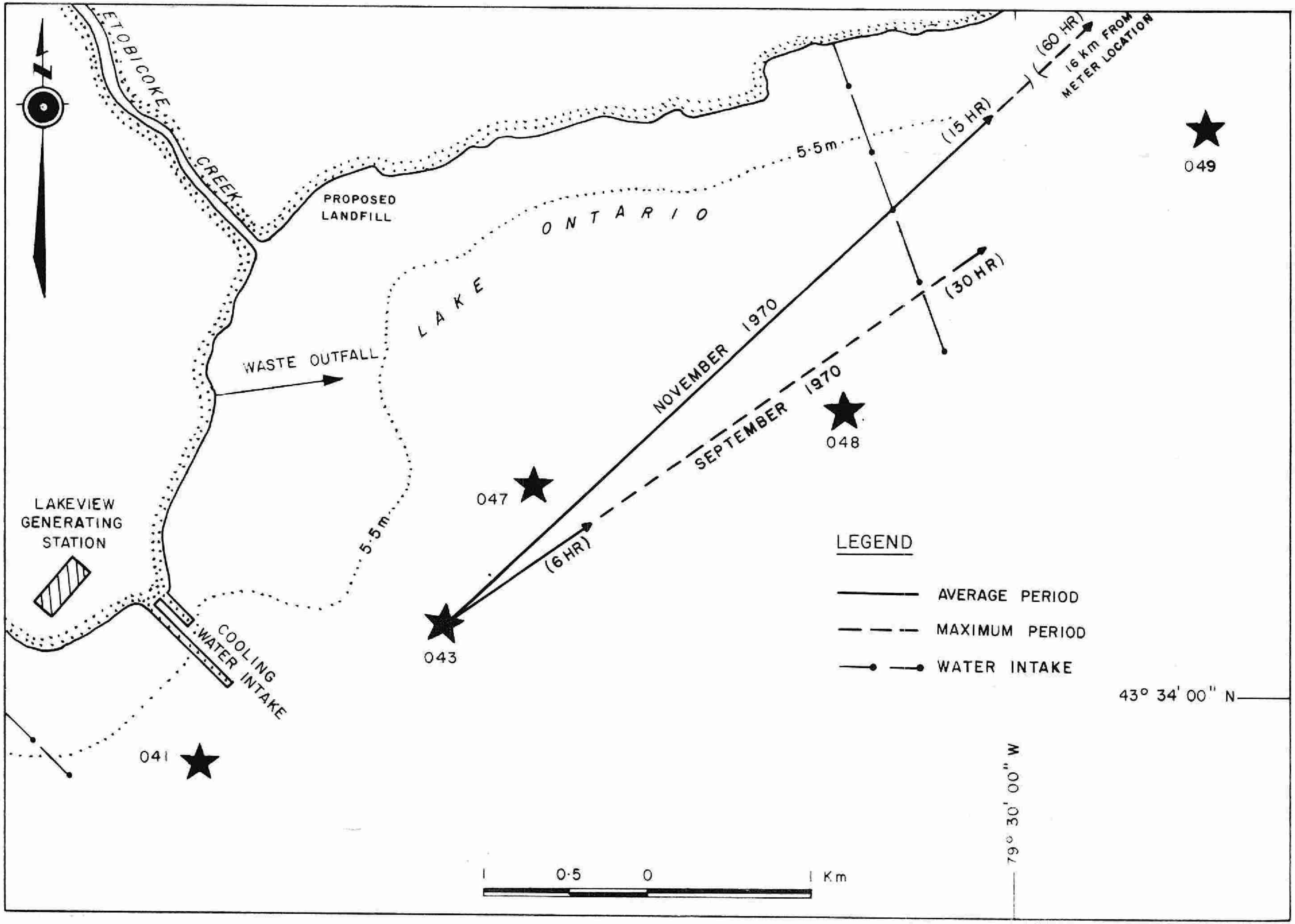

Fig. 5 Mean distances travelled

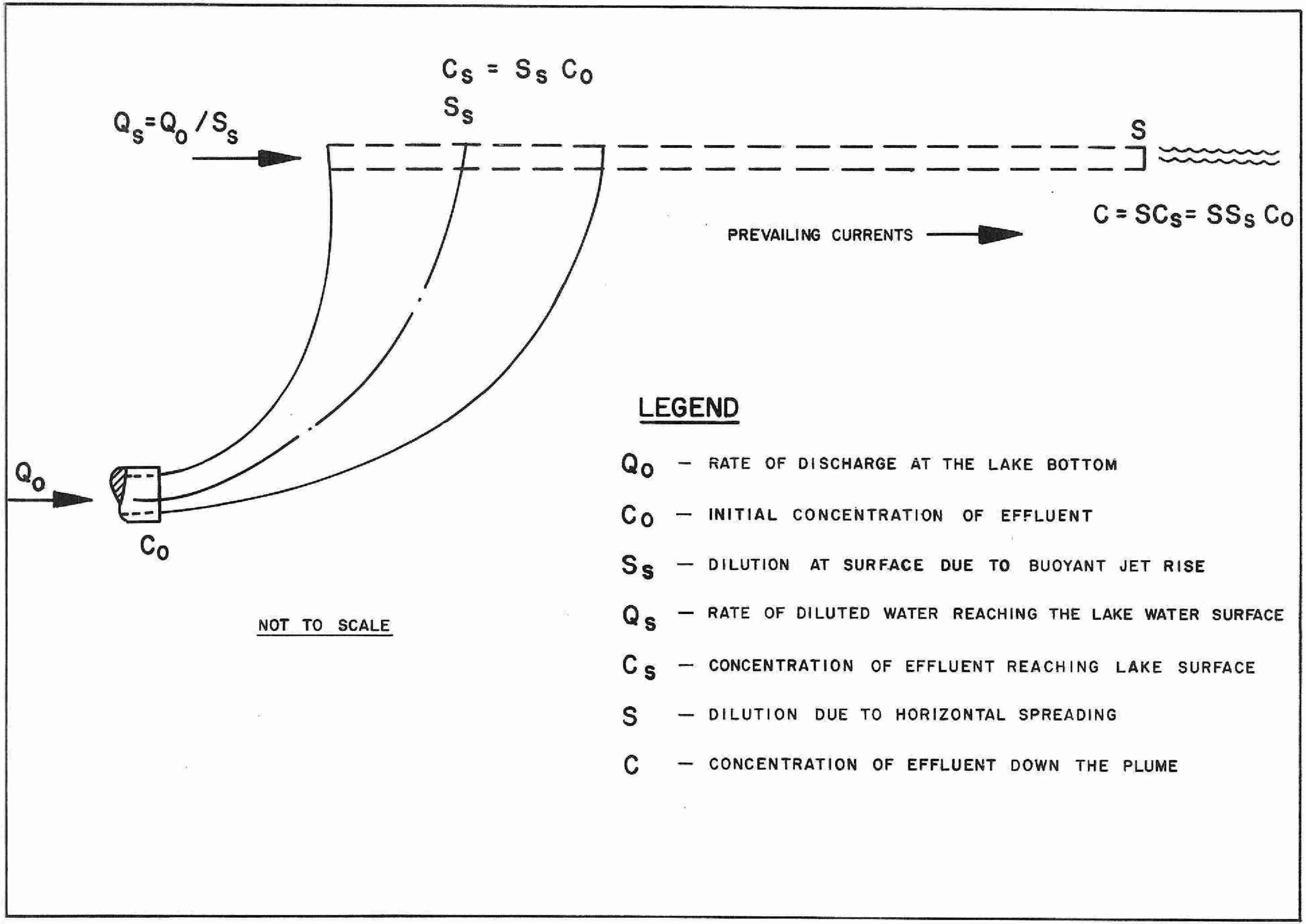

Fig. 6 Schematic diagram of effluent dilution

APPENDIX I

Meter Operating Log and In Situ Calibrations

Table 1.1 presents in situ calibrations by comparing drogue results with current meter results. The operating logs of current meters are presented in Tables 1.2 to 1.5.

TABLE 1.1

Drogue and Meter Comparisons

Date 1970	Time (Hours)	Drogue		Meter 041		Meter 043	
		Speed cm/sec	Direction to Degrees	Speed cm/sec	Direction to Degrees	Speed cm/sec	Direction to Degrees
Jun 12	1000	2.92	52			0.73	60
Jun 12	1045	5.15	20	2.83	355		
Jun 25	1130	1.94	203			0.91	206
Jun 25	1200	2.56	263	0.0	307		
Jul 30	1230	6.20	250	5.13	250		
Aug 13	1240	13.33	53			6.5	60
Aug 18	1750	4.58	160	3.6	270	9.0	240
Sep 30	1255	6.41	176			0.07	147

TABLE 1.2

Location 041 Operating Log

Location: 79° 32' 44"W; 43° 33' 48"N

Depth of Water: 31.0 feet, (9.5 m.)

Depth of Current Meter: 11.3 feet (3.4 m.) from bottom

Current Meter Details: Serial # 144, 159 and 164, Plessey M021

Date 1970	Time (Hours)		Service
	In	Out	
May 21	1115		Meter installed
Jun 8			Spar buoy could not be located
Jun 9			Re-surveyed spar buoy
Jun 11			Located tower, spar buoy had become water-logged and sank. Installed new spar buoy.
Jun 12			Drogue trackings
Jun 25			Drogue trackings
Jul 2	1040	1005	Changed bearings, "O" ring, dessicator, batteries and tape; drogue trackings.
Jul 21	1045	1030	Meter checked and working O.K.
Jul 30	1240	1230	Meter O.K., drogue trackings
Aug 13	1325	1320	Meter changed, drogue trackings
Sep 30			Tower could not be located
Oct 4	1315	1240	Tower located, meter working, changed "O" ring, bearings, dessicator, battery and tape. Re-attached a new spar buoy

TABLE 1.3

Location 043 Operating Log

Location: 79° 31' 54"W; 43° 34' 08"N

Depth of Water: 31.0 feet (9.5 m.)

Depth of Current Meter: 9.8 feet (3.0 m) from bottom

Current Meter Details: Serial # 144 and 272, Plessey M021

Date 1970	Time (Hours)		Service
	In	Out	
May 21	1409		Meter installed
Jun 8	1020	1005	Meter checked and found O.K.
Jun 12			Drogue trackings
Jun 25			Drogue trackings
Jul 2			Drogue trackings
Jul 21	0945	0955	Meter working O.K.
Jul 30	1210	1200	Meter O.K., drogue trackings
Aug 13	1235	1220	Meter changed, drogue trackings
Sep 30	1240	1155	Changed bearings, "O" ring, battery, dessicator and tape. Drogue trackings.
(1971) Dec 9	1440		Meter installed
Dec 15			Surveyed spar
(1972) Feb 9			Drogue trackings
Mar 27		1155	Meter removed

TABLE 1.4

Location 047 Operating Log

Location: 79° 31' 32" W; 43° 34' 30" N

Depth of Water: 31.0 feet (9.5 m.)

Depth of Current Meter: 10 feet (3.0 m.) from bottom

Current Meter Details: Serial # 159, Plessey M021

Date	Time (Hours)		Service
	In	Out	
(1971)			
Dec 21	1320		Meter installed
Dec 22			Surveyed spar
(1972)			
Feb 9			Drogue trackings
Mar 27		1240	Drogue trackings, meter removed

TABLE 1.5

Location 049 Operating Log

Location: 79° 29' 15" W; 43° 35' 21" N

Depth of Water: 45 feet (13.7 m.)

Depth of Current Meter: 11 feet (3.3 m.) from bottom

Current Meter Details: Serial # 278, Geodyne 850

Date	Time (Hours)		Service
	In	Out	
(1971)			
Dec 8	1145		Meter installed
Dec 15			Surveyed spar
(1972)			
Jun 2		1030	Meter removed

APPENDIX II

Frequency tables (2.01 to 2.33) for currents at locations 041, 043, 045, 047 and 049 are presented along with those of wind for the corresponding periods at Toronto Islands (obtained from Atmospheric Environment Services, Environment Canada).

TABLE 2.01 PERIOD: JUNE, 1970

FREQUENCY TABLE - METER 04100

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.626	1.458	3.726	4.839	4.314	2.778	1.644	0.973	20.856
0.31 - 2.99	0.347	3.149	6.899	5.555	11.139	7.660	1.829	0.579	37.338
3.00 - 5.99	0.069	3.056	4.629	0.810	7.176	5.486	0.624	0.069	21.921
6.00 - 8.99	0.000	2.245	2.431	0.000	0.764	2.708	0.347	0.000	8.495
9.00 - 11.99	0.000	1.806	0.949	0.000	0.833	1.482	0.046	0.000	5.116
12.00 - 14.99	0.000	1.157	0.995	0.000	0.000	1.852	0.000	0.000	4.005
15.00 -	0.000	0.416	0.833	0.000	0.000	1.018	0.000	0.000	2.269
COLUMN SUMS	1.042	13.287	20.462	11.204	24.906	22.984	4.490	1.621	100.000

RESULTANT CURRENT IS 1.166 CM/SEC. AT 145.28 DEGREES   MEAN CURRENT IS 3.60 CM/SEC.   PERSISTENCE IS 0.32

TOTAL No. READINGS 4320   MAXIMUM CURRENT IS 18.910 CM/SEC.

TABLE 2.02 PERIOD: JUNE, 1970

FREQUENCY TABLE - METER 04300

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	1.020	6.493	1.275	2.620	1.810	0.741	0.209	0.232	14.402
0.31 - 2.99	2.180	16.303	5.450	3.571	3.827	4.430	2.597	1.229	39.587
3.00 - 5.99	3.942	8.488	2.366	0.765	0.627	3.989	2.435	2.782	25.394
6.00 - 8.99	0.788	7.188	0.533	0.116	0.326	0.881	2.783	1.067	13.683
9.00 - 11.99	0.070	3.061	0.000	0.000	0.000	0.533	0.348	0.184	4.198
12.00 - 14.99	0.255	1.206	0.000	0.000	0.000	0.347	0.139	0.039	2.041
15.00 -	0.093	0.046	0.000	0.000	0.000	0.139	0.140	0.278	0.696
COLUMN SUMS	8.348	42.785	9.624	7.072	6.590	11.060	8.650	5.865	100.000

RESULTANT CURRENT IS 1.379 CM/SEC. AT 19.52 DEGREES

MEAN CURRENT IS 3.49 CM/SEC.

PERSISTENCE IS 0.39

TOTAL No. READINGS 4312

MAXIMUM CURRENT IS 20.49 CM/SEC.

TABLE 2.03 PERIOD: JUNE, 1970

FREQUENCY TABLE - METER 04500

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	1.296	1.344	0.927	2.686	2.686	5.975	0.973	0.973	16.860
0.31 - 2.99	2.409	8.568	5.002	6.716	10.513	7.456	2.826	1.945	45.438
3.00 - 5.99	2.362	2.593	1.250	2.548	5.837	5.049	1.436	0.926	22.001
6.00 - 8.99	1.435	3.242	0.417	0.417	2.594	0.232	0.092	0.602	9.032
9.00 - 11.99	1.251	1.918	0.000	0.000	0.880	0.231	0.000	0.093	5.373
12.00 - 14.99	0.139	1.158	0.000	0.000	0.000	0.000	0.000	0.000	1.297
15.00 -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
COLUMN SUMS	8.892	18.823	7.596	12.367	22.510	18.943	5.327	4.539	100.000

RESULTANT CURRENT IS 0.530 CM/SEC. AT 89.68 DEGREES

MEAN CURRENT IS 2.98 CM/SEC.

PERSISTENCE IS 0.18

TOTAL No. READINGS 2159

MAXIMUM CURRENT IS 14.580 CM/SEC.

TABLE 2.04 PERIOD: JUNE, 1970

WIND FREQUENCY TABLE

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	2.778	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.778
0.31 - 2.99	0.000	0.417	0.278	0.833	0.833	3.333	0.139	0.417	6.250
3.00 - 5.99	0.139	0.556	1.806	0.972	3.194	6.528	0.556	0.278	14.028
6.00 - 8.99	0.972	3.056	2.778	1.250	3.750	1.250	1.667	2.500	22.500
9.00 - 11.99	1.111	2.639	4.444	0.694	3.333	0.556	1.250	2.222	16.944
12.00 - 14.99	1.806	1.389	2.639	0.833	3.056	0.417	2.778	4.028	17.083
15.00 - 26.99	2.916	3.750	1.250	0.139	3.055	0.695	3.333	4.861	20.417
COLUMN SUMS	9.722	11.806	13.194	4.722	17.222	12.306	9.722	14.306	100.000

RESULTANT CURRENT IS 1.003 M.P.H. AT 290 DEGREES

MEAN CURRENT IS 9.75 M.P.H.

PERSISTENCE IS 0.10

TOTAL No. READINGS 720

MAXIMUM CURRENT IS 25.00 M.P.H.

TABLE 2.05 PERIOD: JULY, 1970

FREQUENCY TABLE - METER 0410 0

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	1.392	4.576	6.169	5.362	5.607	7.492	3.612	1.413	35.621
0.31 - 2.99	1.257	6.909	8.547	4.599	7.357	8.882	2.490	0.606	40.646
3.00 - 5.99	0.044	3.590	2.176	0.244	1.504	3.388	0.404	0.044	11.373
6.00 - 8.99	0.045	1.704	0.515	0.067	0.359	3.141	0.112	0.000	5.944
9.00 - 11.99	0.045	1.076	0.538	0.089	0.022	2.086	0.135	0.000	3.993
12.00 - 14.99	0.022	0.807	0.090	0.000	0.000	0.404	0.022	0.000	1.346
15.00 -	0.000	0.830	0.044	0.000	0.000	0.202	0.000	0.000	1.077
COLUMN SUMS	2.805	19.492	18.079	10.274	14.849	25.595	6.775	2.063	100.000

RESULTANT CURRENT IS 0.499 CM/SEC. AT 134.53 DEGREES MEAN CURRENT IS 2.26 CM/SEC. PERSISTENCE IS 0.22

TOTAL No. READINGS 4458 MAXIMUM CURRENT IS 18.85 CM/SEC.

TABLE 2.06 PERIOD: JULY, 1970

FREQUENCY TABLE - METER 04300

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	3.643	3.694	3.544	2.620	3.245	3.694	2.895	2.149	25.480
0.31 - 2.99	10.606	7.137	5.665	6.464	3.569	7.113	4.716	1.847	47.118
3.00 - 5.99	3.369	3.095	2.071	1.048	1.323	4.068	1.148	0.998	17.120
6.00 - 8.99	0.399	0.824	0.000	0.000	0.050	2.995	0.749	0.275	5.291
9.00 - 11.99	0.499	0.649	0.000	0.000	0.000	2.021	0.973	0.200	4.342
12.00 - 14.99	0.225	0.250	0.000	0.000	0.000	0.000	0.000	0.175	0.649
15.00 -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
COLUMN SUMS	18.742	15.648	11.280	10.132	8.186	19.890	10.482	5.640	100.000

RESULTANT CURRENT IS 0.335 CM/SEC. AT 289.33 DEGREES MEAN CURRENT IS 2.30 CM/SEC. PERSISTENCE IS 0.15

TOTAL No. READINGS 4007 MAXIMUM CURRENT IS 13.83 CM/SEC.

TABLE 2.07 PERIOD: JULY, 1970

FREQUENCY TABLE - METER 04500

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.582	0.537	0.762	1.433	0.717	0.717	0.269	0.090	5.108
0.31 - 2.99	5.779	9.857	7.706	10.081	6.944	5.825	2.061	3.091	51.344
3.00 - 5.99	4.480	4.167	1.209	3.136	3.988	3.450	2.554	1.881	24.866
6.00 - 8.99	2.284	2.464	0.941	0.135	1.792	3.270	1.120	0.224	12.231
9.00 - 11.99	1.120	1.927	0.492	0.403	0.000	0.717	0.269	0.000	4.928
12.00 - 14.99	0.000	0.583	0.090	0.000	0.000	0.224	0.000	0.000	0.896
15.00 -	0.000	0.627	0.000	0.000	0.000	0.000	0.000	0.000	0.627
COLUMN SUMS	14.245	20.162	11.200	15.188	13.441	14.203	6.273	5.286	100.000

RESULTANT CURRENT IS 0.565 CM/SEC. AT 72.31 DEGREES

MEAN CURRENT IS 3.44 CM/SEC.

PERSISTENCE IS 0.16

TOTAL No. READINGS 2232

MAXIMUM CURRENT IS 21.130 CM/SEC.

TABLE 2.08 PERIOD: JULY, 1970

WIND FREQUENCY TABLE

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	1.882	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.882
0.31 - 2.99	0.134	0.941	0.672	0.538	2.419	5.645	0.538	0.538	11.425
3.00 - 5.99	0.000	0.941	2.688	2.823	4.704	8.333	2.016	0.806	22.312
6.00 - 8.99	0.538	2.823	4.704	1.075	4.167	3.898	0.672	2.285	20.161
9.00 - 11.99	0.806	2.823	5.376	0.000	3.228	2.823	1.210	3.091	19.355
12.00 - 14.99	0.403	2.285	3.360	0.403	2.285	2.823	1.344	2.151	14.516
15.00 - 23.99	0.000	0.537	1.344	0.000	1.479	4.599	1.344	3.360	10.350
COLUMN SUMS	3.763	10.349	18.145	4.839	18.280	25.269	7.124	12.231	100.000

RESULTANT CURRENT IS 1.072 M.P.H. AT 198 DEGREES

MEAN CURRENT IS 8.04 M.P.H.

PERSISTENCE IS 0.13

TOTAL No. READINGS 744

MAXIMUM CURRENT IS 23.00 M.P.H.

TABLE 2.09 PERIOD: AUGUST, 1970

FREQUENCY TABLE - METER 04300

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.404	2.420	0.942	0.897	1.256	0.785	0.897	0.604	8.204
0.31 - 2.99	2.802	5.425	4.909	2.936	2.756	3.452	2.533	2.846	27.662
3.00 - 5.99	2.332	7.307	3.833	0.628	2.644	2.914	3.295	1.905	24.860
6.00 - 8.99	2.466	5.761	1.076	0.829	0.896	3.340	2.600	1.143	18.113
9.00 - 11.99	2.152	5.044	0.381	0.044	0.022	3.339	1.389	0.695	13.069
12.00 - 14.99	0.875	2.197	0.000	0.000	0.000	1.099	1.076	0.201	5.447
15.00 -	0.829	0.471	0.000	0.000	0.000	1.322	0.022	0.000	2.645
COLUMN SUMS	11.860	28.625	11.141	5.334	7.574	16.251	11.812	7.394	100.000

RESULTANT CURRENT IS 1.243 CM/SEC. AT 355.95 DEGREES

MEAN CURRENT IS 5.39 CM/SEC.

PERSISTENCE IS 0.23

TOTAL No. READINGS 4461

MAXIMUM CURRENT IS 20.16 CM/SEC.

TABLE 2.10 PERIOD: AUGUST, 1970

WIND FREQUENCY TABLE

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	4.301	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.301
0.31 - 2.99	0.134	0.403	0.134	0.403	1.210	0.941	2.823	1.613	7.661
3.00 - 5.99	1.613	1.613	2.823	0.806	2.688	4.839	3.629	2.957	20.968
6.00 - 8.99	4.301	0.806	5.914	3.360	3.360	3.360	2.823	5.645	29.570
9.00 - 11.99	1.210	0.672	4.839	1.075	1.613	2.957	1.478	3.763	17.608
12.00 - 14.99	0.134	0.000	2.016	0.000	1.478	2.554	2.285	2.957	11.425
15.00 - 23.99	0.000	0.000	1.075	0.000	0.134	0.672	2.957	3.628	8.467
COLUMN SUMS	11.694	3.495	16.801	5.645	10.484	15.323	15.995	20.565	100.000

RESULTANT CURRENT IS 1.758 M.P.H. AT 275 DEGREES

MEAN CURRENT IS 7.70 M.P.H.

PERSISTENCE IS 0.23

TOTAL No. READINGS 744

MAXIMUM CURRENT IS 22.00 M.P.H.

TABLE 2.11 PERIOD: SEPTEMBER, 1970

FREQUENCY TABLE - METER 04100

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.139	19.190	1.805	2.245	0.277	0.000	0.000	0.000	23.557
0.31 - 2.99	0.278	27.893	1.088	0.902	0.416	0.092	0.116	0.000	30.787
3.00 - 5.99	0.185	19.167	0.417	0.671	0.162	0.625	1.250	0.116	22.593
6.00 - 8.99	0.093	11.389	0.370	0.000	0.000	0.139	0.556	0.023	12.569
9.00 - 11.99	0.000	5.579	0.093	0.000	0.000	0.000	0.000	0.000	5.671
12.00 - 14.99	0.000	2.616	0.278	0.000	0.000	0.000	0.000	0.000	2.894
15.00 -	0.000	1.111	0.718	0.000	0.000	0.000	0.000	0.000	1.829
COLUMN SUMS	0.694	86.944	4.769	3.819	0.856	0.856	1.921	0.139	100.000

RESULTANT CURRENT IS 3.394 CM/SEC. AT 50.57 DEGREES MEAN CURRENT IS 3.61 CM/SEC. PERSISTENCE IS 0.94

TOTAL No. READINGS 4320 MAXIMUM CURRENT IS 18.640 CM/SEC.

TABLE 2.12 PERIOD: SEPTEMBER, 1970

FREQUENCY TABLE - METER 04300

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 337.49	ROW SUMS
0.00 - 0.30	2.853	1.462	2.274	1.368	1.113	4.175	0.904	1.044	15.194
0.31 - 2.99	3.525	6.309	3.943	2.993	3.804	6.216	4.361	1.067	32.220
3.00 - 5.99	1.508	4.107	1.322	0.650	2.668	7.864	4.570	0.116	22.802
6.00 - 8.99	0.302	5.799	0.255	0.000	0.278	6.750	1.717	0.000	15.101
9.00 - 11.99	0.209	2.296	0.139	0.000	0.093	5.451	0.255	0.000	8.444
12.00 - 14.99	0.093	2.250	0.000	0.000	0.023	2.969	0.162	0.000	5.498
15.00 -	0.000	0.070	0.000	0.000	0.000	0.673	0.000	0.000	0.742
COLUMN SUMS	8.490	22.292	7.933	5.010	7.980	34.099	11.969	2.227	100.000

RESULTANT CURRENT IS 1.082 CM/SEC. AT 239.75 DEGREES MEAN CURRENT IS 4.36 CM/SEC. PERSISTENCE IS 0.24

TOTAL No. READINGS 4311 MAXIMUM CURRENT IS 19.78 CM/SEC.

TABLE 2.13 PERIOD: SEPTEMBER, 1970

WIND FREQUENCY TABLE

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	2.361	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.361
0.31 - 2.99	0.139	0.556	1.528	0.417	0.972	0.556	0.417	0.556	5.139
3.00 - 5.99	0.694	2.361	2.500	2.778	2.639	5.694	2.917	3.889	23.472
6.00 - 8.99	0.972	3.472	4.028	1.389	2.500	3.472	3.889	5.417	25.139
9.00 - 11.99	0.972	2.917	2.361	0.556	2.361	2.639	3.333	2.222	17.361
12.00 - 14.99	0.000	4.028	2.778	0.000	1.111	0.694	3.333	3.194	15.139
15.00 - 32.99	0.000	2.223	1.389	0.000	0.417	1.389	3.890	2.084	26.389
COLUMN SUMS	5.139	15.556	14.583	5.139	10.000	14.444	17.778	17.361	100.000

RESULTANT CURRENT IS 1.506 M.P.H. AT 297 DEGREES

MEAN CURRENT IS 8.51 M.P.H.

PERSISTENCE IS 0.18

TOTAL No. READINGS 720

MAXIMUM CURRENT IS 30.00 M.P.H.

TABLE 2.14 PERIOD: OCTOBER, 1970

FREQUENCY TABLE - METER 04300

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.448	0.784	3.158	0.851	1.680	0.695	0.807	1.097	9.521
0.31 - 2.99	6.317	6.519	3.271	2.375	2.957	3.494	2.688	2.039	29.659
3.00 - 5.99	3.898	15.412	0.582	0.426	1.075	9.946	1.994	0.179	33.513
6.00 - 8.99	0.202	9.073	0.560	0.022	0.246	9.901	0.112	0.000	20.116
9.00 - 11.99	0.112	3.181	0.000	0.000	0.134	2.285	0.000	0.000	5.712
12.00 - 14.99	0.000	0.851	0.000	0.000	0.000	0.000	0.000	0.000	0.851
15.00 - 17.99	0.000	0.627	0.000	0.000	0.000	0.000	0.000	0.000	0.627
COLUMN SUMS	10.977	36.447	7.572	3.674	6.093	26.322	5.600	3.315	100.000

RESULTANT CURRENT IS 0.83 CM/SEC. AT 8.77 DEGREES

MEAN CURRENT IS 4.26 CM/SEC.

PERSISTENCE IS 0.19

TOTAL No. READINGS 4464

MAXIMUM CURRENT IS 17.05 CM/SEC.

TABLE 2.15 PERIOD: NOVEMBER, 1970

FREQUENCY TABLE - METER 04300

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES) 337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.138	2.294	2.385	0.464	1.413	0.810	0.949	0.000	8.455
0.31 - 2.99	3.104	14.222	2.038	2.131	3.057	3.892	1.483	0.602	30.530
3.00 - 5.99	0.811	12.323	0.000	0.000	0.000	6.555	1.830	0.278	22.168
6.00 - 8.99	0.139	6.972	0.000	0.000	0.000	5.467	0.278	0.000	12.856
9.00 - 11.99	0.000	3.567	0.000	0.000	0.000	6.139	0.000	0.000	9.706
12.00 - 14.99	0.000	0.695	0.000	0.000	0.000	7.528	0.000	0.000	8.223
15.00 - 29.99	0.000	0.000	0.000	0.000	0.000	8.061	0.000	0.000	8.061
COLUMN SUMS	4.193	40.074	4.424	2.594	4.841	38.453	4.540	0.880	100.000

RESULTANT CURRENT IS 2.31 CM/SEC. AT 247.5 DEGREES MEAN CURRENT IS 6.06 CM/SEC. PERSISTENCE IS 0.38

TOTAL No. READINGS 4317 MAXIMUM CURRENT IS 27.48 CM/SEC.

TABLE 2.16

PERIOD: DECEMBER, 1971

FREQUENCY TABLE - METER 043

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES) 337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.57	0.00	1.20	0.00	0.63	0.51	2.65	1.20	6.76
0.31 - 2.99	1.64	5.62	2.40	1.05	4.74	5.62	3.66	1.45	26.18
3.00 - 5.99	0.70	6.25	2.46	0.06	0.06	9.53	1.58	0.38	21.02
6.00 - 8.99	0.13	3.98	0.44	0.06	0.13	12.06	0.44	0.25	17.49
9.00 - 11.99	0.38	1.96	0.00	0.00	0.00	6.95	0.57	0.13	9.99
12.00 - 14.99	0.00	2.21	0.00	0.00	0.00	6.06	0.06	0.00	8.33
15.00 -	0.00	4.54	0.00	0.00	0.00	5.68	0.00	0.00	10.22
COLUMN SUMS	3.42	24.56	6.50	1.17	4.93	46.41	8.96	3.41	100.00

RESULTANT CURRENT IS 1.81 CM/SEC. AT 242 DEGREES

MEAN CURRENT IS 6.91 CM/SEC.

PERSISTENCE IS 0.26

TOTAL No. READINGS 1584

MAXIMUM CURRENT IS 34.41 CM/SEC.

TABLE 2.17

PERIOD: DECEMBER, 1971

FREQUENCY TABLE - METER 047

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	3.63	8.51	7.53	5.02	1.12	0.56	0.28	0.14	26.79
0.31 - 2.99	0.98	13.81	8.37	1.95	9.48	7.67	0.42	0.84	43.52
3.00 - 5.99	0.28	5.44	0.00	0.42	1.40	5.44	0.00	0.00	12.98
6.00 - 8.99	0.14	0.42	0.00	0.00	0.84	6.97	0.00	0.00	8.37
9.00 - 11.99	0.42	0.28	0.00	0.00	0.00	3.49	0.00	0.00	4.19
12.00 - 14.99	0.28	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.70
15.00	0.70	0.84	1.95	0.00	0.00	0.00	0.00	0.00	3.49
COLUMN SUMS	6.43	29.30	18.27	7.39	12.84	24.13	0.70	0.98	100.00

RESULTANT CURRENT IS 0.64 CM/SEC. AT 134 DEGREES

MEAN CURRENT IS 3.06 CM/SEC.

PERSISTENCE IS 0.21

TOTAL No. READINGS 717

MAXIMUM CURRENT IS 26.36 CM/SEC.

TABLE 2.18

PERIOD: DECEMBER, 1971

FREQUENCY TABLE - METER 049

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.31 - 2.99	4.44	3.49	2.81	1.31	2.22	5.16	5.75	1.77	26.95
3.00 - 5.99	1.22	8.42	6.25	0.86	1.40	7.65	2.81	0.18	28.79
6.00 - 8.99	0.00	7.34	4.03	0.09	0.27	3.08	0.36	0.00	15.17
9.00 - 11.99	0.00	2.58	2.22	0.00	0.09	3.22	0.18	0.00	8.29
12.00 - 14.99	0.00	0.73	3.44	0.09	0.09	2.13	0.14	0.00	6.62
15.00 -	0.00	1.36	4.67	0.09	0.00	7.61	0.45	0.00	14.18
COLUMN SUMS	5.66	23.92	23.42	2.44	4.07	28.85	9.69	1.95	100.00

RESULTANT CURRENT IS 0.73 CM/SEC. AT 137 DEGREES

MEAN CURRENT IS 7.79 CM/SEC.

PERSISTENCE IS 0.09

TOTAL No. READINGS 2208

MAXIMUM CURRENT IS 36.96 CM/SEC.

TABLE 2.19

PERIOD: DECEMBER, 1971

FREQUENCY TABLE - WIND

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES) 337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.42
0.31 - 2.99	0.27	0.00	0.27	1.08	0.13	0.81	0.27	0.40	3.23
3.00 - 5.99	0.27	0.54	1.75	1.48	0.94	0.81	1.34	1.88	9.01
6.00 - 8.99	1.08	1.75	2.15	1.21	1.88	0.81	2.42	3.01	14.38
9.00 - 11.99	2.02	1.21	1.75	2.02	1.48	3.76	2.82	2.55	17.61
12.00 - 14.99	1.34	1.61	2.15	1.61	0.67	2.55	3.63	2.28	15.86
15.00	1.21	0.81	9.68	0.00	0.40	7.39	14.38	2.69	37.50
COLUMN SUMS	8.60	5.91	17.74	7.93	5.51	16.13	25.27	12.90	100.00

RESULTANT CURRENT IS 2.86 M.P.H. AT 261 DEGREES

MEAN CURRENT IS 12.78 M.P.H.

PERSISTENCE IS 0.22

TOTAL No. READINGS 744

MAXIMUM CURRENT IS 36.00 M.P.H.

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TABLE 2.20

PERIOD: JANUARY, 1972

FREQUENCY TABLE - METER 043

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.36	0.49	2.91	0.22	0.00	3.54	1.30	0.36	9.18
0.31 - 2.99	1.75	3.32	2.82	1.30	0.90	6.36	1.84	0.23	18.62
3.00 - 5.99	0.54	6.63	1.00	0.00	0.13	10.44	0.76	0.31	19.81
6.00 - 8.99	0.09	4.75	0.58	0.00	0.00	10.71	0.18	0.14	16.45
9.00 - 11.99	0.00	0.36	0.00	0.00	0.00	14.65	0.09	0.00	15.10
12.00 - 14.99	0.00	0.49	0.00	0.00	0.00	8.65	0.00	0.00	9.14
15.00	0.00	0.22	0.00	0.00	0.00	11.61	0.00	0.00	11.83
COLUMN SUMS	2.74	16.26	7.31	1.52	1.03	65.96	4.17	1.04	100.00

RESULTANT CURRENT IS 5.43 CM/SEC. AT 236 DEGREES

MEAN CURRENT IS 7.51 CM/SEC.

PERSISTENCE IS 0.72

TOTAL No. READINGS 2232

MAXIMUM CURRENT IS 29.39 CM/SEC.

TABLE 2.21

PERIOD: JANUARY, 1972

FREQUENCY TABLE - METER 047

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.45	0.63	9.52	1.08	1.39	1.30	0.32	0.14	14.83
0.31 - 2.99	5.07	7.63	13.65	2.42	2.42	4.26	1.84	1.39	38.68
3.00 - 5.99	1.98	2.38	2.47	2.96	4.08	6.69	0.23	0.14	20.93
6.00 - 8.99	0.14	0.00	0.99	0.72	2.83	11.58	0.23	0.09	16.58
9.00 - 11.99	0.00	0.00	0.09	0.00	1.53	3.99	0.05	0.00	5.66
12.00 - 14.99	0.00	0.00	0.00	0.00	0.45	1.89	0.00	0.00	2.34
15.00	0.00	0.00	0.00	0.00	0.18	0.85	0.00	0.00	1.03
COLUMN SUMS	7.64	10.64	26.72	7.18	12.88	30.56	2.67	1.76	100.00

RESULTANT CURRENT IS 2.19 CM/SEC. AT 199 DEGREES

MEAN CURRENT IS 3.84 CM/SEC.

PERSISTENCE IS 0.57

TOTAL No. READINGS 2228

MAXIMUM CURRENT IS 16.33 CM/SEC.

OWRC 10-430

TABLE 2.22

PERIOD: JANUARY, 1972

FREQUENCY TABLE - METER 049

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.31 - 2.99	6.28	7.66	2.39	1.24	0.64	1.45	1.85	2.86	24.37
3.00 - 5.99	2.99	11.26	2.08	0.57	2.08	4.40	4.64	0.84	28.86
6.00 - 8.99	0.00	7.63	1.48	0.10	0.54	6.59	1.24	0.07	17.65
9.00 - 11.99	0.00	7.26	0.77	0.00	0.17	0.60	0.13	0.00	8.93
12.00 - 14.99	0.00	4.87	0.91	0.03	0.03	0.30	0.03	0.00	6.17
15.00 -	0.00	9.34	3.70	0.03	0.00	0.94	0.00	0.00	14.01
COLUMN SUMS	9.27	48.02	11.33	1.97	3.46	14.28	7.89	3.77	100.00

RESULTANT CURRENT IS 4.41 CM/SEC. AT 60 DEGREES

MEAN CURRENT IS 7.72 CM/SEC.

PERSISTENCE IS 0.58

TOTAL No. READINGS 2976

MAXIMUM CURRENT IS 36.48 CM/SEC.

TABLE 2.23

PERIOD: JANUARY, 1972

FREQUENCY TABLE - WIND

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.48
0.31 - 2.99	0.00	0.00	0.13	0.00	0.40	0.40	0.67	0.13	1.73
3.00 - 5.99	0.67	0.27	0.94	0.81	0.13	0.54	1.21	0.67	5.24
6.00 - 8.99	1.48	0.94	1.08	0.67	0.54	2.02	3.63	2.42	12.78
9.00 - 11.99	2.29	0.67	2.55	1.34	0.54	3.23	4.84	1.48	16.94
12.00 - 14.99	1.61	0.13	0.67	1.34	0.67	2.82	6.59	0.67	14.50
15.00	0.54	0.00	1.21	0.54	0.40	18.41	22.85	3.36	47.31
COLUMN SUMS	8.07	2.01	6.58	4.70	2.68	27.42	39.79	8.73	100.00

RESULTANT CURRENT IS 10.20 M.P.H. AT 255 DEGREES

MEAN CURRENT IS 14.83 M.P.H.

PERSISTENCE IS 0.69

TOTAL No. READINGS 744

MAXIMUM CURRENT IS 42.00 M.P.H.

TABLE 2.24

PERIOD: FEBRUARY, 1972

FREQUENCY TABLE - METER 043

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	1.34	3.74	9.72	3.07	1.01	6.71	3.45	2.78	31.82
0.31 - 2.99	0.38	6.32	3.64	0.67	0.77	9.01	2.16	0.24	23.19
3.00 - 5.99	0.00	7.04	0.43	0.00	0.00	6.37	0.53	0.00	14.37
6.00 - 8.99	0.00	6.94	0.00	0.00	0.00	3.45	0.00	0.00	10.39
9.00 - 11.99	0.00	4.12	0.00	0.00	0.00	4.80	0.00	0.00	8.92
12.00 - 14.99	0.00	1.77	0.00	0.00	0.00	2.35	0.00	0.00	4.12
15.00	0.00	2.11	0.00	0.00	0.00	5.13	0.00	0.00	7.24
COLUMN SUMS	1.72	32.04	13.79	3.74	1.78	37.82	6.14	3.02	100.00

RESULTANT CURRENT IS 0.44 CM/SEC. AT 237 DEGREES

MEAN CURRENT IS 4.55 CM/SEC.

PERSISTENCE IS 0.10

TOTAL No. READINGS 2088

MAXIMUM CURRENT IS 24.07 CM/SEC.

TABLE 2.25

PERIOD: FEBRUARY, 1972

FREQUENCY TABLE - METER 047

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.14	0.14	14.58	0.19	0.38	0.19	1.96	0.67	18.25
0.31 - 2.99	9.34	7.52	19.92	1.20	1.10	3.11	1.44	2.35	45.98
3.00 - 5.99	5.75	1.77	7.57	0.19	0.96	3.16	0.10	0.81	20.31
6.00 - 8.99	1.39	0.29	3.26	0.29	0.62	3.26	0.14	0.10	9.35
9.00 - 11.99	0.10	0.05	0.00	0.00	2.16	3.35	0.05	0.10	5.81
12.00 - 14.99	0.00	0.00	0.00	0.00	0.24	0.10	0.00	0.00	0.34
15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLUMN SUMS	16.72	9.77	45.33	1.87	5.46	13.17	3.69	4.03	100.00

RESULTANT CURRENT IS 0.67 CM/SEC. AT 121 DEGREES

MEAN CURRENT IS 2.89 CM/SEC.

PERSISTENCE IS 0.23

TOTAL No. READINGS 2088

MAXIMUM CURRENT IS 12.81 CM/SEC.

TABLE 2.26

PERIOD: FEBRUARY, 1972

FREQUENCY TABLE - METER 049

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.31 - 2.99	2.19	2.87	2.12	1.15	0.75	5.35	4.89	3.20	22.52
3.00 - 5.99	4.45	10.24	2.73	0.40	0.90	5.28	6.50	1.98	32.48
6.00 - 8.99	0.22	6.39	1.37	0.00	0.36	5.89	3.45	0.07	17.75
9.00 - 11.99	0.00	2.12	2.08	0.00	0.03	4.27	1.51	0.00	10.01
12.00 - 14.99	0.00	1.15	0.90	0.00	0.00	4.20	0.29	0.00	6.54
15.00 -	0.00	4.96	0.76	0.00	0.00	4.85	0.14	0.00	10.71
COLUMN SUMS	6.86	27.73	9.96	1.55	2.04	29.84	16.78	5.25	100.00

RESULTANT CURRENT IS 0.68 CM/SEC. AT 270 DEGREES

MEAN CURRENT IS 7.17 CM/SEC.

PERSISTENCE IS 0.10

TOTAL No. READINGS 2784

MAXIMUM CURRENT IS 43.74 CM/SEC.

TABLE 2.27

PERIOD: FEBRUARY, 1972

FREQUENCY TABLE - WIND

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	3.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.88
0.31 - 2.99	0.14	0.00	1.01	0.43	0.14	0.29	0.14	0.58	2.73
3.00 - 5.99	1.29	1.01	1.72	1.15	0.72	1.01	1.44	2.87	11.21
6.00 - 8.99	1.58	1.15	2.59	1.44	1.29	2.30	3.59	5.17	19.11
9.00 - 11.99	2.30	0.43	1.44	2.16	1.58	1.29	5.46	3.59	18.25
12.00 - 14.99	1.72	0.29	1.29	1.44	0.86	3.02	2.87	2.30	13.79
15.00	4.31	0.29	4.74	1.58	0.43	2.87	12.36	4.45	31.03
COLUMN SUMS	15.22	3.17	12.79	8.20	5.02	10.78	25.86	18.96	100.00

RESULTANT CURRENT IS 4.28 M.P.H. AT 288 DEGREES

MEAN CURRENT IS 11.86 M.P.H.

PERSISTENCE IS 0.36

TOTAL No. READINGS 696

MAXIMUM CURRENT IS 34.00 M.P.H.

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TABLE 2.28 PERIOD: MARCH, 1972

FREQUENCY TABLE - METER 043

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.90	6.80	16.09	1.79	0.79	2.06	7.33	2.06	37.82
0.31 - 2.99	0.90	11.24	2.74	0.84	0.63	6.75	4.06	0.47	27.63
3.00 - 5.99	0.00	6.70	0.42	0.00	0.00	5.75	0.16	0.00	13.03
6.00 - 8.99	0.00	4.01	0.00	0.00	0.00	2.64	0.00	0.00	6.65
9.00 - 11.99	0.00	3.96	0.00	0.00	0.00	3.59	0.00	0.00	7.55
12.00 - 14.99	0.00	1.90	0.00	0.00	0.00	1.58	0.00	0.00	3.48
15.00	0.00	3.85	0.00	0.00	0.00	0.00	0.00	0.00	3.85
COLUMN SUMS	1.80	38.46	19.25	2.63	1.42	22.37	11.55	2.53	100.00

RESULTANT CURRENT IS 1.24 CM/SEC. AT 43 DEGREES

MEAN CURRENT IS 3.62 CM/SEC.

PERSISTENCE IS 0.34

TOTAL No. READINGS 1896

MAXIMUM CURRENT IS 28.98 CM/SEC.

TABLE 2.29

PERIOD: MARCH, 1972

FREQUENCY TABLE - METER 047

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.60	1.90	17.86	2.34	0.87	0.38	1.41	0.49	25.85
0.31 - 2.99	6.14	14.12	14.71	1.19	1.57	5.59	1.30	2.12	46.75
3.00 - 5.99	6.19	3.15	0.71	0.33	3.00	4.02	0.05	0.16	17.61
6.00 - 8.99	0.49	1.19	0.00	0.00	2.17	2.01	0.11	0.11	6.08
9.00 - 11.99	0.00	1.74	0.00	0.00	0.54	0.71	0.00	0.00	2.99
12.00 - 14.99	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.71
15.00 -	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLUMN SUMS	13.42	22.81	33.28	3.86	8.15	12.71	2.87	2.88	100.00

RESULTANT CURRENT IS 0.46 CM/SEC. AT 57 DEGREES

MEAN CURRENT IS 2.31 CM/SEC.

PERSISTENCE IS 0.20

TOTAL No. READINGS 1842

MAXIMUM CURRENT IS 14.20 CM/SEC.

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TABLE 2.30

PERIOD: MARCH, 1972

FREQUENCY TABLE - METER 049

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES) 337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.31 - 2.99	3.02	3.53	5.61	4.30	3.83	5.71	13.44	5.24	44.68
3.00 - 5.99	0.30	6.25	3.53	0.81	0.67	4.64	5.58	0.84	22.62
6.00 - 8.99	0.10	4.50	0.87	0.17	0.20	2.82	2.15	0.00	10.81
9.00 -11.99	0.03	1.65	0.14	0.14	0.00	1.95	0.94	0.00	4.85
12.00 -14.99	0.00	1.65	0.87	0.07	0.00	2.49	0.54	0.00	5.62
15.00	0.00	1.18	0.03	0.07	0.14	9.41	0.51	0.07	11.41
COLUMN SUMS	3.45	18.76	11.05	5.56	4.84	27.02	23.16	6.15	100.00

RESULTANT CURRENT IS 2.43 CM/SEC. AT 238 DEGREES

MEAN CURRENT IS 6.45 CM/SEC.

PERSISTENCE IS 0.38

TOTAL No. READINGS 2976

MAXIMUM CURRENT IS 40.02 CM/SEC.

TABLE 2.31

PERIOD: MARCH, 1972

FREQUENCY TABLE - WIND

SPEED (M.P.H.)	DIRECTION COMING FROM (DEGREES)							
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 0.30	3.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09
0.31 - 2.99	0.40	0.54	0.13	0.40	0.40	0.40	0.27	0.54	3.08
3.00 - 5.99	1.61	1.34	2.29	1.75	1.34	0.94	1.75	1.34	12.36
6.00 - 8.99	1.75	2.15	4.57	0.81	1.61	1.75	2.82	6.86	22.32
9.00 - 11.99	1.21	1.48	3.36	0.81	1.21	1.34	2.69	6.32	18.42
12.00 - 14.99	0.13	1.75	2.42	0.81	0.27	1.21	2.29	5.65	14.53
15.00	0.13	1.88	9.14	0.13	0.67	3.23	6.05	4.97	26.20
COLUMN SUMS	8.32	9.14	21.91	4.71	5.50	8.87	15.87	25.68	100.00

RESULTANT CURRENT IS 1.90 M.P.H. 325 DEGREES

MEAN CURRENT IS 10.68 M.P.H.

PERSISTENCE IS 0.18

TOTAL No. READINGS 7 4 4

MAXIMUM CURRENT IS 28.00 M.P.H.

OWRC 10-430

TABLE 2.32

PERIOD: JUNE, 1972

FREQUENCY TABLE - METER 049

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 2.99	0.00	0.00	0.00	0.11	0.04	0.00	0.00	0.00	0.15
3.00 - 5.99	0.59	0.78	0.30	0.48	0.67	0.60	0.32	0.41	4.65
6.00 - 8.99	4.58	5.80	2.49	1.63	2.16	3.94	1.79	2.16	24.55
9.00 - 11.99	4.95	4.39	2.08	1.86	1.90	1.86	1.27	1.41	19.72
12.00 - 14.99	2.57	3.16	0.48	1.79	2.42	1.19	0.56	0.86	13.02
15.00 - 17.99	2.23	1.93	0.15	1.12	1.08	1.08	0.41	0.78	8.78
18.00 -	10.34	6.47	1.45	0.26	5.36	3.09	0.71	1.38	29.05
COLUMN SUMS	25.26	22.55	6.96	7.25	13.62	11.75	5.54	6.99	100.00

RESULTANT CURRENT IS 3.84 CM/SEC. AT 26 DEGREES

MEAN CURRENT IS 4.86 CM/SEC.

PERSISTENCE IS 0.79

TOTAL No. READINGS 2688

MAXIMUM CURRENT IS 15.99 CM/SEC.

TABLE 2.33

PERIOD: JULY, 1972

FREQUENCY TABLE - METER 049

SPEED (CM/SEC.)	DIRECTION COMING FROM (DEGREES)								
	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	ROW SUMS
0.00 - 2.99	0.00	0.00	0.00	0.06	0.19	0.25	0.06	0.00	0.57
3.00 - 5.99	2.29	1.53	0.57	0.95	1.84	2.86	2.16	2.73	14.93
6.00 - 8.99	8.39	6.48	1.72	3.81	5.15	6.54	4.64	5.08	41.81
9.00 - 11.99	2.03	2.54	1.14	2.29	3.05	3.49	2.60	2.13	19.28
12.00 - 14.99	0.83	1.08	0.45	1.91	1.08	2.49	0.57	1.02	9.42
15.00 - 17.99	0.13	0.26	0.38	0.89	1.40	1.72	0.57	0.32	5.66
18.00 -	0.00	3.37	0.19	0.89	1.08	2.04	0.83	0.00	8.39
COLUMN SUMS	13.66	15.25	4.45	10.80	13.79	19.40	11.44	11.28	100.00

RESULTANT CURRENT IS 1.08 CM/SEC. AT 234 DEGREES

MEAN CURRENT IS 3.35 CM/SEC.

PERSISTENCE IS 0.32

TOTAL No. READINGS 1574

MAXIMUM CURRENT IS 13.61 CM/SEC.

APPENDIX III

Total coliforms greater than 300 counts/ml at R.L. Clark water intake are statistically compared with concurrent water movements at location 043. The currents are resolved in four major compass directions, going to north, east, south and west. The data is then grouped and presented in Table 3.01 so that each group contains all consecutive coliform readings greater than 300 counts/ml. The predominant current direction and period of each group are also included in Table 3.01, which is then utilized for statistical tests.

Tables 3.02 and 3.03 are similar to Table 3.01 but for free ammonia concentrations greater than 0.02 mg/l for 1970 and 1972 data, respectively.

TABLE 3.01

Group #	Reading #	Date 1970	Predominant Current Direction to
1	1-2	Jun 3	SW*
2	3	14	SW
3	4-5	15	SW
4	6	18	NE
5	7-8	26	SW
6	9	27	SW
7	10	28	NE
8	11	Jul 4	NW
9	12	6	S
10	13-21	20-22	NW
11	22	23	0
12	23	23	NE
13	24	23	NE
14	25	24	NE
15	26	26	E
16	27-28	27	SW
17	29-32	Aug 1-2	SW
18	33	5	NE
19	34	5	NW
20	35	7	SE
21	36-41	8-10	SW
22	42-43	12	SE
23	44	13	SW
24	45	13	SE
25	46	17	NW
26	47-48	18	SW
27	49	18	SE
28	50-55	19-20	SW
29	56	21	E
30	57-66	22-25	SW
31	67-68	26	SW
32	69-81	30-2	NW
33	82-85	Sep 3-4	SW
34	86-88	6-8	NE
35	89-90	8	SW
36	91-95	9-10	SW
37	96-97	13-14	NE
38	98	15	SW
39	99	16	NW
40	100	17	NE
41	101	18	E

*For explanation, please see footnotes of Table 2.02

TABLE 3.01 (Cont'd)

Group #	Reading #	Date 1970	Predominant Current Direction to
42	102	Sep 18	SW
43	103-105	19-20	SW
44	106-107	21	SW
45	108-118	24-27	SW
46	119-120	29	NE
47	121	Oct 1	NE
48	122-127	3-5	NE
49	128	5	S
50	129-130	7-8	0
51	131-141	8-13	SW
52	142	13	SW
53	143	14	SW
54	144	14	SW
55	145	14	SW
56	146-157	16-20	NE
57	158-159	21	SW
58	160-164	22-23	SW
59	165	25	SW
60	166-180	26-30	SW
61	181-185	Nov 1-2	0
62	186	3	SW
63	187	6	SW
64	188	7	SW
65	189-192	8-9	SW
66	193	11	NW
67	194	12	0
68	195	14	SW
69	196-198	15-16	SW
70	199-204	16-17	NE
71	205	18	NE
72	206-208	18-19	NE
73	209-212	20-21	NE
74	213	22	NE
75	214	24	SW
76	215	25	NE

TABLE 3.02

Group #	Reading #	Date 1970	Predominant Current Direction to
1	1-2	Jun 11	NE*
2	3-5	14-15	SW
3	6	16	SW
4	7-11	18-20	NE
5	12	22	NW
6	13-14	23	SW
7	15	Jul 5	NW
8	16	11	SW
9	17-18	20	NW
10	19	23	NE
11	20	24	NE
12	21	27	0
13	22	28	0
14	23	29	0
15	24	30	0
16	25	31	0
17	26	Aug 19	NW
18	27	Sep 25	NW
19	28	Oct 1	NE
20	29-31	9	SW
21	32-33	11	0
22	34	14	SW

*NE - Currents going to Northeast
NW - Currents going to Northwest
SE - Currents going to Southeast
SW - Currents going to Southwest
E - Currents going to East
0 - No movement

TABLE 3.02 (Cont'd)

Group #	Reading #	Date 1970	Predominant Current Direction to
23	35-36	Oct 16	NE
24	37	18	NE
25	38	19	NE
26	39-40	20	SW
27	41	20	SW
28	42	21	SW
29	43-47	22-23	SW
30	48	25	SW
31	49	26	SW
32	50-55	27-28	SW
33	56-61	29-30	SW
34	62-68	Nov 1-3	SW
35	69-74	6-8	NE
36	75	9	SW
37	76	9	SW
38	77	10	SW
39	78-82	11-12	SW
40	83	13	SW
41	84	14	SW
42	85	16	NE
43	86-87	17	NE
44	88-93	18-19	NE

TABLE 3.03

Group #	Reading #	Date	Predominant Current Direction to
1	1-21	Dec 10-11	NE*
2	22-23	12	NE
3	24-25	12	NE
4	26	12	SE
5	27-40	13-14	NE
6	41-50	15-16	NE
7	51-53	18	SW
8	54-65	18-19	SW
9	66-76	20-21	NE
10	77-78	21	NE
11	79	21	NE
12	80-82	24	NE
13	83	25	SW
14	84-92	25-26	SW
15	93-95	27	SW
16	96-99	27	SW
17	100-102	30	SW
18	103-116	30-31	SW
19	117-146	Jan 1-3	NE
20	147-157	4-5	SW
21	158-159	5	SW
22	160	6	NE
23	161-164	8	SW
24	165-169	9	NE
25	170-178	11-12	NE
26	179	15	NE
27	180-188	22-23	NE
28	189-191	24	0
29	192-196	25	NE
30	197-210	Feb 2-3	SW
31	211-218	4	NE
32	219	5	NE
33	220	8	NE
34	221-227	13-14	SW
35	228	14	NE
36	229-237	14-15	NE

*For explanation, please see footnotes of Table 2.02

TABLE 3.03 (Cont'd)

Group #	Reading #	Date 1972	Predominant Current Direction to
37	238	Feb 17	SW
38	239-252	18-19	SW
39	253-261	19-20	SW
40	262-263	21	NE
41	264	21	NE
42	265-270	21-22	NE
43	271-283	22-23	0
44	284-329	23-28	NE
45	330-346	28-1	SW
46	347-348	Mar 1	SW
47	349	2	SW
48	350-370	2-4	SW
49	371-374	4	SW
50	375-385	5	NE
51	386-406	6-8	NE
52	407-408	9	NE
53	409-417	11-12	SW
54	418	12	SW
55	419-430	13-14	SW
56	431-435	14-15	SW
57	436-449	16-17	SW
58	450	17	0
59	451-455	18	E
60	456	18	NE
61	457	18	0
62	458-459	19	0
63	460	19	0
64	461-474	19-20	0
65	475-481	21-22	SW
66	482-484	23	SW
67	485-496	23-24	SW
68	497	25	SW
69	498-499	25	SW
70	500	26	0
71	501-504	27	0

APPENDIX IV

Diffuser Design

One method of diffuser design was outlined by Rawn (1961) and is briefly described as follows:

The rate of discharge, q_n, from the n^{th} port in the side of a pipe is expressed by:

$$q_n = C_n \cdot a_n \sqrt{2gE_n} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where C_n is the discharge co-efficient for n^{th} port;

a_n is the cross-sectional area of n^{th} port;

E_n is the total head in the main flow at n^{th} port.

The discharge co-efficient C_n is not a constant along the diffuser, but is a function of the ratio $\frac{V_n^2}{2g} / E_{n+1}$ (see Figure 4.1).

$$V_n = V_{n-1} + \frac{q_n}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$\text{Velocity head} = \frac{V_n^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where V_n = mean pipe velocity between n^{th} port and $(n+1)^{th}$ port;

g = acceleration due to gravity;

A = cross-sectional area of the pipe.

The head loss (h_n) due to pressure difference between the inside and the outside of the diffuser port, just upstream of the n^{th} port, is expressed by:

$$h_n = f \frac{L_n}{D} \frac{V_n^2}{2g} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4)$$

where f = Darcy friction factor;

L_n = distance between $(n+1)^{th}$ and n^{th} port;

D = pipe diameter;

$$E_{n+1} = E_n + h_n + \frac{\Delta S}{S} \Delta Z_n \quad . \; . \; . \; . \; . \; . \; . \quad (5)$$

where S = specific gravity of sewage

ΔS = difference in specific gravity between receiving water and sewage;

ΔZ_n = change in elevation between $(n+1)^{th}$ and n^{th} port (measured to centre of port; positive when $(n-1)^{th}$ port is not as deep as n^{th} port).

The five equations, outlined above, are adequate to design a suitable diffuser. However, it is necessary to decide the number of ports and spacings. The sum of all port areas must remain less than the diffuser pipe area. The spacing between any two ports is generally greater than the diffuser pipe diameter. The design requires some trial and error to arrive at a satisfactory arrangement.

Having decided the number of ports and spacing, it is easy to compute the average value of discharge through a typical port. The last port of the diffuser is considered the first port for this analysis (n=1) and the analysis progresses towards the shore i.e. n increases towards the shore. The flow through the first port (n=1) will be somewhat larger than the average flow. An estimate of q_1 is first made. Utilizing equation (1), E_1 is computed and then equations (2) through (5) are used to compute other parameters for the first port. Knowing $\frac{V_1^2}{2g}/E_2$, C_2 is found from figure 4.1. The stepwise computations are repeated for all ports.

If the total flow through all ports or the head loss results are not satisfactory, the design calculations are repeated with varying number of ports and spacings until a satisfactory solution is obtained.

The results of a diffuser design for a peak flow of 687 cfs and average flow of 279 cfs through a 12 ft. diameter reinforced concrete pipe are presented in Tables 4.1 and 4.2 and Figure 4.2.

TABLE 4.1

Design Calculations for Peak Flow

Q = 687 cfs
A = 113 ft, Pipe dia = 12 ft
Port dia = 2 ft, Port area = 3.14 ft^2
30 ports @ 20' centres

$\frac{\Delta s}{s} \Delta Z = .00002$

$h_{fn} = 0.01938 \frac{V_n^2}{2g}$

$E_1 = .138643$

Port # n	C_n	q_n	V_n	$\frac{V_n^2}{2g}$	h_{fn}	E_{n+1}	$\frac{V^2}{2g}/E_{n+1}$
1	0.91	27.00	0.25	0.00088	0.000017	1.38647	0.000
2	0.90	26.70	0.48	0.00351	0.000067	1.38656	0.003
3	0.90	26.70	0.71	0.00786	0.000152	1.38673	0.006
4	0.90	26.70	0.95	0.01395	0.000270	1.38702	0.010
5	0.90	26.70	1.18	0.02180	0.000420	1.38746	0.016
6	0.90	26.70	1.42	0.03130	0.000607	1.38809	0.023
7	0.89	26.40	1.65	0.04250	0.000823	1.38890	0.031
8	0.88	26.13	1.89	0.05522	0.001070	1.39002	0.040
9	0.87	25.85	2.11	0.06940	0.001345	1.39140	0.050
10	0.86	25.56	2.34	0.08508	0.001648	1.39306	0.061
11	0.85	25.28	2.56	0.10212	0.001979	1.39505	0.073
12	0.84	25.00	2.79	0.12050	0.002335	1.39740	0.086

TABLE 4.1 (Cont'd)

Port # n	C_n	q_n	V_n	$\frac{V_n^2}{2g}$	h_{fn}	E_{n+1}	$\frac{V^2}{2g}/E_{n+1}$
13	0.83	24.72	3.00	0.14017	0.002720	1.40015	0.100
14	0.81	24.30	3.22	0.16100	0.003120	1.40330	0.115
15	0.80	23.88	3.44	0.18300	0.003540	1.40700	0.130
16	0.78	23.31	3.64	0.20500	0.003980	1.41080	0.146
17	0.76	22.90	3.84	0.22900	0.004400	1.41500	0.160
18	0.75	22.48	4.04	0.25000	0.004900	1.42000	0.178
19	0.73	21.92	4.23	0.28000	0.005400	1.42600	0.195
20	0.71	21.36	4.42	0.30400	0.005900	1.43500	0.212
21	0.70	21.10	4.61	0.33000	0.006400	1.44000	0.230
22	0.68	20.55	4.79	0.36000	0.006900	1.44500	0.247
23	0.66	19.99	4.97	0.38000	0.007400	1.45000	0.260
24	0.65	19.74	5.14	0.41000	0.008000	1.46000	0.280
25	0.63	19.18	5.31	0.44000	0.008500	1.47000	0.298
26	0.62	18.93	5.48	0.47000	0.009000	1.48000	0.310
27	0.61	18.69	5.64	0.49000	0.009600	1.49000	0.330
28	0.59	18.13	5.81	0.52000	0.010140	1.49800	0.350
29	0.57	17.58	5.96	0.55000	0.010700	1.50800	0.366
30	0.56	17.33	6.11	0.58000	0.011200	1.51960	0.380
Total		690.81			0.132500		

TABLE 4.2

Design Calculations for Average Flow

$Q = 279$ cfs
$A = 113\ ft^2$, Pipe dia = 12 ft
Port dia = 2 ft, Port area = $3.14\ ft^2$
10 ports @ 60' centres
$\Delta S_{\Delta} Z = 0.00006$; $h_{fn} = 0.05814 \dfrac{V_n^2}{2g}$
$\overline{E_1^S} = 1.54476$

Port # n	C_n	q_n	V_n	$\frac{V_n^2}{2g}$	h_{fn}	E_{n+1}	$\frac{V_n^2}{2g}/E_{n+1}$
1	0.91	28.50	0.25	0.00098	0.00005	1.54488	0.001
2	0.91	28.50	0.50	0.00395	0.00022	1.54516	0.003
3	0.91	28.50	0.76	0.00889	0.00051	1.54574	0.006
4	0.91	28.50	1.00	0.01580	0.00091	1.54672	0.010
5	0.91	28.50	1.26	0.02470	0.00143	1.54821	0.016
6	0.90	28.20	1.51	0.03545	0.00205	1.55032	0.023
7	0.89	27.92	1.76	0.04799	0.00278	1.55317	0.031
8	0.88	27.63	2.00	0.06228	0.00361	1.55685	0.040
9	0.87	27.51	2.25	0.07834	0.00455	1.56146	0.050
10	0.86	27.08	2.49	0.09595	0.00557	1.56710	0.061
Total		280.84			0.02168		

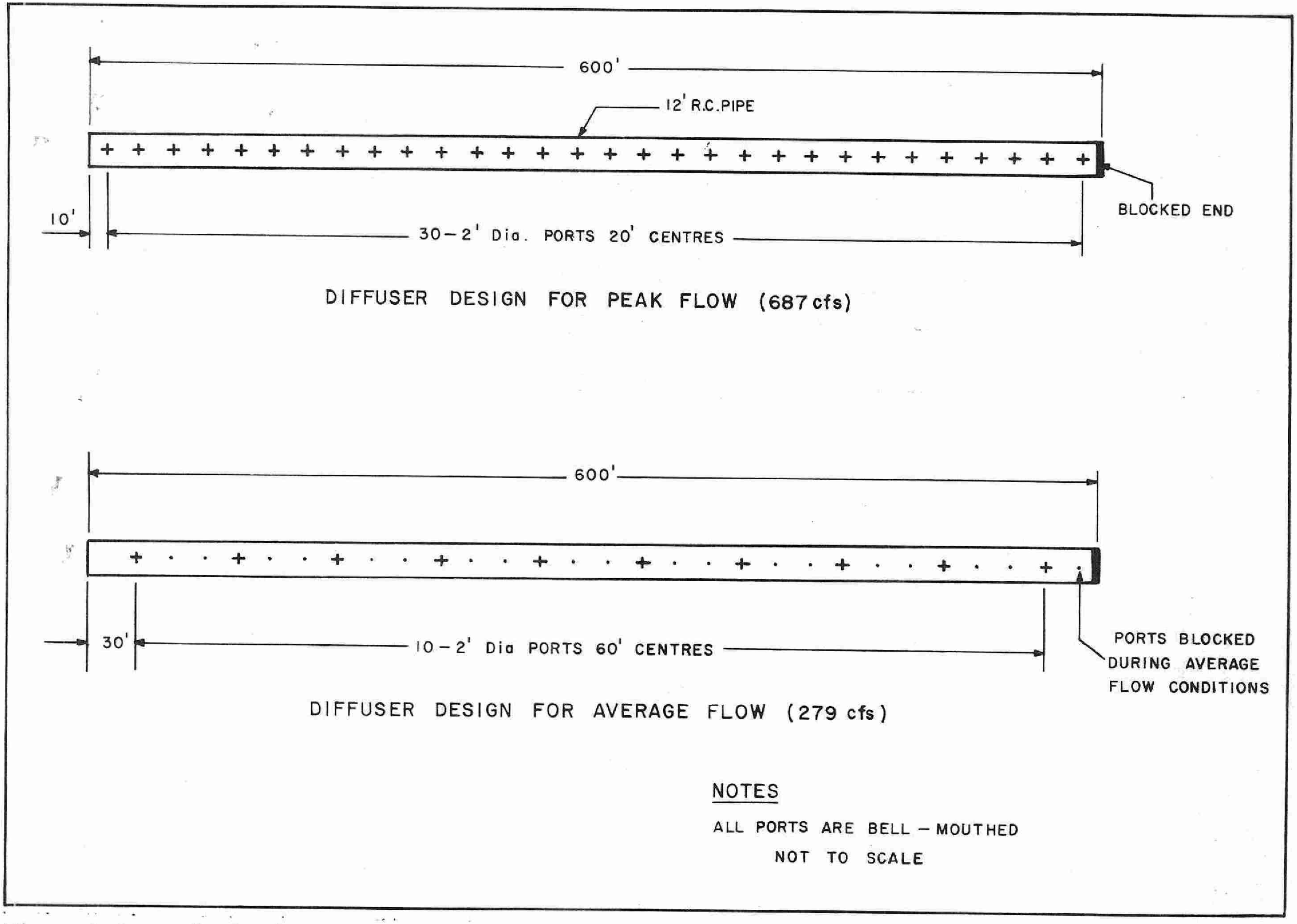

Fig. 4.2 Typical diffuser design

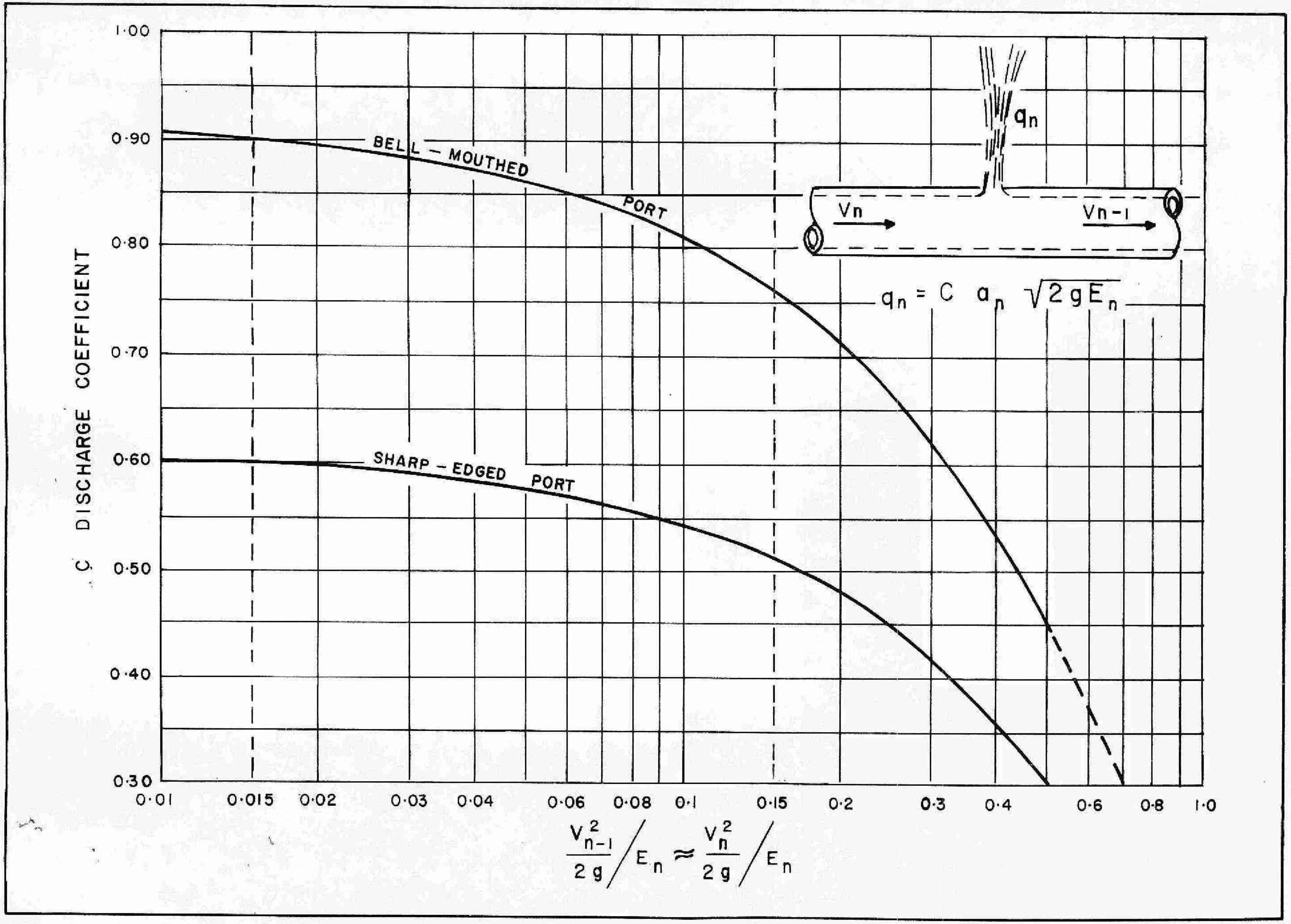

Fig. 4.1 Discharge coefficient for a small port on the side of a pipe (after Rawn, 1961)